

SECTION 26 05 11**REQUIREMENTS FOR ELECTRICAL INSTALLATIONS****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. This section applies to all sections of Division 26.
- B. Furnish and install electrical wiring, systems, equipment and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, cable, switchboards, switchgear, panelboards, motor control centers, and other items and arrangements for the specified items are shown on drawings.
- C. Electrical service entrance equipment (arrangements for temporary and permanent connections to the utility's system) shall conform to the utility's requirements. Coordinate fuses, circuit breakers and relays with the utility's system, and obtain utility approval for sizes and settings of these devices.
- D. Wiring ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways accordingly sized. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

- A. References to the International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL) and National Fire Protection Association (NFPA) are minimum installation requirement standards.
- B. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.

1.3 TEST STANDARDS

- A. All materials and equipment shall be listed, labeled or certified by a nationally recognized testing laboratory to meet Underwriters Laboratories, Inc., standards where test standards have been established. Equipment and materials which are not covered by UL Standards will be accepted provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed; Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
2. Labeled; Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. Certified; equipment or product which:
 - a. Has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
 - b. Production of equipment or product is periodically inspected by a nationally recognized testing laboratory.
 - c. Bears a label, tag, or other record of certification.
4. Nationally recognized testing laboratory; laboratory which is approved, in accordance with OSHA regulations, by the Secretary of Labor.
5. Provide NETA test for all electrical equipment such as: switchgear, switchboards, panelboards, transformers, medium voltage cables and low voltage conductors.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

- A. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.
- B. Product Qualification:
 1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.

2. The Government reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

Applicable publications listed in all Sections of Division are the latest issue, unless otherwise noted.

1.6 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts shall be available.

B. When more than one unit of the same class or type of equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.

2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.

3. Components shall be compatible with each other and with the total assembly for the intended service.

4. Constituent parts which are similar shall be the product of a single manufacturer.

D. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

E. When Factory Testing Is Specified:

1. The Government shall have the option of witnessing factory tests. The contractor shall notify the VA through the COTR a minimum of 15 working days prior to the manufacturers making the factory tests.

2. Four copies of certified test reports containing all test data shall be furnished to the COTR prior to final inspection and not more than 90 days after completion of the tests.

3. When equipment fails to meet factory test and re-inspection is required, the contractor shall be liable for all additional expenses, including expenses of the Government.

1.7 EQUIPMENT REQUIREMENTS

Where variations from the contract requirements are requested in accordance with Section 00 72 00, GENERAL CONDITIONS and Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.8 EQUIPMENT PROTECTION

- A. Equipment and materials shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.
 - 1. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Equipment shall include but not be limited to switchgear, switchboards, panelboards, transformers, motor control centers, motor controllers, uninterruptible power systems, enclosures, controllers, circuit protective devices, cables, wire, light fixtures, electronic equipment, and accessories.
 - 2. During installation, equipment shall be protected against entry of foreign matter; and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.
 - 3. Damaged equipment shall be, as determined by the COTR, placed in first class operating condition or be returned to the source of supply for repair or replacement.
 - 4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
 - 5. Damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

- A. All electrical work must comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J, OSHA Part 1910 subpart S and OSHA Part 1910 subpart K in addition to other references required by contract.
- B. Job site safety and worker safety is the responsibility of the contractor.
- C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished

in this manner for the required work, the following requirements are mandatory:

1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.
2. Electricians must wear personal protective equipment while working on energized systems in accordance with NFPA 70E.
3. Before initiating any work, a job specific work plan must be developed by the contractor with a peer review conducted and documented by the COTR and Medical Center staff. The work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used and exit pathways.
4. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the COTR.
- D. For work on existing stations, arrange, phase and perform work to assure electrical service for other buildings at all times. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.
- E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.
- F. Coordinate location of equipment and conduit with other trades to minimize interferences.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

- A. Equipment location shall be as close as practical to locations shown on the drawings.
- B. Working spaces shall not be less than specified in the NEC for all voltages specified.
- C. Inaccessible Equipment:
 1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
 2. "Conveniently accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over

obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

1.11 EQUIPMENT IDENTIFICATION

- A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as panelboards, cabinets, motor controllers (starters), safety switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.
- B. Nameplates for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Nameplates for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 1/2 inch [12mm] high. Nameplates shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

1.12 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.
- C. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary for the Government to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.
- D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
 - 1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
 - 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 - 3. Submit each section separately.

E. The submittals shall include the following:

1. Information that confirms compliance with contract requirements.
Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
2. Elementary and interconnection wiring diagrams for communication and signal systems, control systems and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
3. Parts list which shall include those replacement parts recommended by the equipment manufacturer.

F. Manuals: Submit in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1. Maintenance and Operation Manuals: Submit as required for systems and equipment specified in the technical sections. Furnish four copies, bound in hardback binders, (manufacturer's standard binders) or an approved equivalent. Furnish one complete manual as specified in the technical section but in no case later than prior to performance of systems or equipment test, and furnish the remaining manuals prior to contract completion.
2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment.
3. Provide a "Table of Contents" and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
4. The manuals shall include:
 - a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
 - b. A control sequence describing start-up, operation, and shutdown.
 - c. Description of the function of each principal item of equipment.
 - d. Installation instructions.
 - e. Safety precautions for operation and maintenance.
 - f. Diagrams and illustrations.
 - g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers and replacement frequencies.
 - h. Performance data.

- i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.
 - j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.
- G. Approvals will be based on complete submission of manuals together with shop drawings.
- H. After approval and prior to installation, furnish the COTR with one sample of each of the following:
- 1. A 300 mm (12 inch) length of each type and size of wire and cable along with the tag from the coils of reels from which the samples were taken.
 - 2. Each type of conduit coupling, bushing and termination fitting.
 - 3. Conduit hangers, clamps and supports.
 - 4. Duct sealing compound.
 - 5. Each type of receptacle, toggle switch, occupancy sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.14 ACCEPTANCE CHECKS AND TESTS

The contractor shall furnish the instruments, materials and labor for field tests.

1.15 TRAINING

- A. Training shall be provided in accordance with Article 1.25, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.
- B. Training shall be provided for the particular equipment or system as required in each associated specification.
- C. A training schedule shall be developed and submitted by the contractor and approved by the COTR at least 30 days prior to the planned training.

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SECTION 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of the high voltage cables.

1.2 RELATED WORK

- A. Bedding of conduits: Section 31 20 00, EARTH MOVING.
- B. General electrical requirement and items that are common to more than one section of Division 26: Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- C. Conduits for high voltage cables: Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- D. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents: Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include splice and termination kit information prior to purchase and installation.
 - 3. Provide cable minimum bend radius, and flammability data.
- C. Samples:
 - 1. After approval and prior to installation, furnish the COTR with a 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils or reels from which the samples were taken. The sample shall contain the manufacturers markings.
- D. Certifications:
 - 1. Factory test reports: Prior to installation of the cables, deliver four copies of the manufacturers certified NEMA WC 71 or WC 74, standard factory test reports to the COTR. Certified copies of test data shall show conformance with the referenced standards and shall be approved prior to delivery of cable.

2. Field Test Reports: Test Reports on the following shall be in accordance with the paragraph entitled "Field Tests for High Voltage Cables" and include the following tests:

- a. High Potential Tests
- b. Dielectric Absorption Tests
- c. Radiographic Tests

After testing, submit four certified copies of each of the graphs specified under field testing, to the COTR. Adequate information shall be included identifying the cable locations, types, voltage rating and sizes.

3. Splices and terminations, after having been installed and tested, deliver four copies of a certificate by the Contractor to the COTR which includes the following:
 - a. A statement that the materials, detail drawings and printed instructions used, are those contained in the kits approved for this contract.
 - b. A statement that each splice and each termination was completely installed without any overnight interruption.
 - c. A statement that field made splices and terminations conform to the following requirements:
 - 1) Pencil the cable insulation precisely.
 - 2) Connector installations:
 - a) Use tools that are designed for the connectors being installed.
 - b) Round and smooth the installed connectors to minimize localized voltage stressing of the insulating materials.
 - 3) Remove contaminants from all surfaces within the splices and terminations before installing the insulating materials.
 - 4) Solder block throughout stranded grounding wires that will penetrate the splicing and terminating materials.
 - 5) Use mirrors to observe the installation of materials on the backsides of the splices and terminations.
 - 6) Eliminate air voids throughout the splices and terminations.
 - 7) Stretch each layer of tape properly during installation.
 - d. List all of the materials purchased and installed for the splices and terminations for this contract including the material descriptions, manufacturer's names, catalog numbers and total quantities.

E. Installer Approval:

1. Employees who install the splices and terminations and test the cables shall have not less than five years of experience splicing and terminating cables which are equal to those being spliced and terminated, including experience with the materials in the kits.
2. Furnish satisfactory proof of such experience for each employee who splices or terminates the cables.

F. Cable Voltage Ratings

1. Medium voltage power cables shall include multiple and single-conductor cable rated as follows:
 - a) 5000 Volts shall be used on 4160 3-phase 60hz distribution systems.

G. Shipment:

1. Cable shall be shipped on reels such that cable will be protected from mechanical injury. Each end of each length of cable shall be hermetically sealed and securely attached to the reel.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the designation only:

1. American Society for Testing and Materials (ASTM):

B3-2001.....Standard Specification for Soft or Annealed
Copper Wire

- B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

386-95 (R2001).....Separable Insulated Connector Systems for Power
Distribution Systems above 600 V

400.2-2005.....Guide for Field Testing of Shielded Power Cable
Systems

404-2000.....Extruded and Laminated Dielectric Shielded
Cable Joints Rated 2500-500,000 Volts

- C. National Electrical Manufacturers Association (NEMA):

WC 71-1999.....Standard for Non-Shielded Cables Rated 2001-
5000 Volts for Use in the Distribution of
Electrical Energy (ICEA S-96-659)

WC 74-2000.....5-46 KV Shielded Power Cable for Use in the
Transmission and Distribution of Electrical
Energy (ICEA S-93-969)

D. National Fire Protection Association (NFPA):

70-2005.....National Electrical Code (NEC)

E. Underwriters Laboratories (UL):

1072-2006 Medium-Voltage Power Cables

PART 2- PRODUCTS**2.1 MATERIAL HIGH VOLTAGE CABLE**

A. High voltage cable shall be in accordance with the NEC and NEMA WC71, WC74 and UL 1072.

B. Shall be single conductor stranded copper conforming to ASTM B3.

C. Insulation:

1. Insulation level shall be 133 percent.

2. Types of insulation:

a. Cable type abbreviation, EPR: Ethylene propylene rubber insulation shall be thermosetting, light and heat stabilized.

D. Conductors and insulation shall be wrapped separately with semiconducting tape.

E. Insulation shall be wrapped with non-magnetic, metallic shielding except for cables for series type lighting systems.

F. Heavy duty, overall protective jackets of chlorosulphonated polyethylene, neoprene or polyvinyl chloride shall enclose every cable.

G. Cable temperature ratings for continuous operation, emergency overload operation and short circuit operation shall be not less than the NEC, NEMA WC71 or NEMA WC74 Standard for the respective cable.

H. Manufacturer's name and other pertinent information shall be marked or molded clearly on the overall outside surface of the jackets, or incorporated on marker tapes within the cables at reasonable intervals.

2.2 MATERIAL, SPLICES AND TERMINATIONS

A. The materials shall be compatible with the conductors, insulations and protective jackets on the cables and wires.

B. The splices shall insulate and protect the conductors not less than the insulation and protective jackets on the cables and wires that protect the conductors. In locations where moisture might be present, the splices shall be watertight. In manholes and handholes the splices shall be submersible.

C. Splicing and Terminating Fittings: Shall be in accordance with IEEE 386, 404.

1. Shall be heavy duty, pressure type fittings, which will assure satisfactory performance of the connections under conditions of

temperature cycling and magnetic forces from available short circuit currents.

2. The fittings shall be suitably designed and the proper size for the cables and wires being spliced and terminated. Terminations to bus shall be with two hole lugs.
3. Where the Government determines that unsatisfactory fittings have been installed, contractor shall replace the unsatisfactory installations with approved fittings at no additional cost to the Government.

D. Splicing and Terminating Kits:

1. General:

- a. Shall be assembled by the manufacturer or supplier of the materials and shall be packaged for individual splices and terminations or for groups of splices and terminations.
 - b. Shall consist of materials designed for the cables being spliced and terminated and shall be suitable for the prevailing environmental conditions.
 - c. Shall include detail drawings and printed instructions for each type of splice and termination being installed, as prepared by the manufacturers of the materials in the kits.
 - d. Detail drawings, and printed instructions shall indicate the cable type, voltage rating, manufacturer's name and catalog numbers for the materials indicated.
 - e. Voltage ratings for the splices and terminations shall be not less than the voltage ratings for the cables on which they are being installed.
 - f. Shall include shielding and stress cone materials.
2. Taped splices and terminations with insulating and semi-conducting rubber tapes shall withstand 200 percent elongation without cracking, rupturing or reducing their electric and self-bonding characteristics by more than 5 percent.
 3. Epoxy resin kits shall be as follows:
 - a. Compatible with the cable insulations and jackets and make the splices watertight and submersible.
 - b. Thermosetting and generate its own heat so that external fire or heat will not be required.
 - c. Set solid and cure in approximately 60 minutes in 21 degree C (70 degree F) ambient temperature.

- d. Not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.
 - e. Furnished in pre-measured quantities, sized for each splice and each termination, with two resin components in an easy mixing plastic bag which will permit mixing the resin without entrapping air or contaminants. Other methods of packaging and mixing the epoxy resin components will be considered for approval, provided they include adequate safeguards to assure precise proportioning of the resin components and to prevent entrapping air and contaminants.
 - f. Use snap-together, longitudinally-split, interlocking seam, transplant mold bodies or taped frameworks, injection fittings and injection gun or pouring equipment. Completely fill voids within the splices and terminations.
- E. Pre-molded Rubber Splices and Terminations:
- 1. Splices and terminations shall be in accordance with IEEE 386, and 404.
 - 2. Pre-molded rubber devices shall have a minimum of 3 mm (0.125 inch) semi-conductive shield material covering the entire housing. Test each rubber part prior to shipment from the factory.
 - 3. Grounding of metallic shields shall be accomplished by a solderless connector enclosed in a watertight rubber housing covering the entire assembly. The grounding device and splice or terminator shall be of same manufacturer to insure electrical integrity of the shielded parts.
 - 4. The pre-molded parts shall be suitable for indoor, outdoor, submersible, or direct-burial applications.

2.3 MATERIAL, FIREPROOFING TAPE

- A. The tape shall consist of a flexible, conformable fabric of organic composition coated one side with flame-retardant elastomer.
- B. The tape shall be self-extinguishing and shall not support combustion. It shall be arc proof and fireproof.
- C. The tape shall not deteriorate when subjected to water, gases, salt water, sewage, or fungus. It shall be resistant to sunlight and ultraviolet light.
- D. The finished application shall withstand a 200 ampere arc for not less than 30 seconds.

- E. Securing tape: Shall be glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (3/4 inch) wide.

2.4 MATERIAL, WARNING TAPE

- A. The tape shall be standard, 76 mm (3 inch) wide, 4-Mil polyethylene detectable type with aluminum backing.
- B. The tape shall be red with black letters indicating "CAUTION BURIED ELECTRIC LINE BELOW".

PART 3 - EXECUTION

3.1 INSTALLATION, HIGH VOLTAGE CABLE

- A. Installation shall be in accordance with the NEC, and as shown on the drawings.
- B. Contractor shall ensure that radii of bends fittings, cable risers, and other conditions are suitable for the cable and conform with the recommendations of the cable manufacturer.
- C. Cable shall be installed in underground duct banks, in conduit above and below grade; inside buildings, on insulator hooks; on racks in wall and ceiling mounted cable trays in utility tunnels and manholes; and by direct burial.
- D. Cables shall be secured with heavy duty cable ties in existing or new trays mounted horizontally, where cable rests on tray bottom.
- E. Cables shall be secured with PVC coated metallic non-metallic cable clamps, straps, hangers, or other approved supporting devices to tunnel walls, ceilings, and in new or existing cable trays mounted vertically, where tray bottom is in a vertical plane.
- F. Contractor shall ensure that all cable tray is properly secured and supported prior to installing new armored cable. Contractor shall add new permanent and/or temporary tray support devices as required to preclude cable tray failure during cable pulling or after cable is installed.
- G. Cable or conductors of a primary distribution system shall be rejected when installed openly in cable trays or openly racked along interior walls; in the same raceway or conduit with AC/DC control circuits or ac power circuits operating at less than 600 volts; or in a manner allowing cable to support its own weight.
- H. Use suitable lubricating compounds on the cables and wires to prevent damage to them during pulling-in. Provide compounds that are not injurious to the cable and wire jackets and do not harden or become adhesive.

- I. Splice the cables and wires only in manholes and accessible junction boxes. Ground shields in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- J. In manholes, trenches and vaults install the cables on suitable porcelain insulators with steel cables racks. Ground cable racks in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- K. In manholes, underground raceways and other outdoors locations:
 - 1. Seal the cable ends prior to pulling them in to prevent the entry of moisture.
 - 2. For ethylene propylene rubber and polyethylene insulated cables, use bags of epoxy resin that are not less than 6 mm (1/4 inch) larger in diameter than the overall diameter of the cable. Clean each end of each cable before installing the epoxy resin over it.

3.2 PROTECTION DURING SPLICING OPERATIONS

Blowers shall be provided to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed.

Waterproof protective coverings shall be available on the work site to provide protection against moisture while a splice is being made.

Pumps shall be used to keep manholes dry during splicing operations.

Under no conditions shall a splice or termination be made with the interior of a cable exposed to moisture. Conductor insulation paper shall be moisture-tested before the splice is made. A manhole ring at least 150 mm (6 inches) above ground shall be used around the manhole entrance to keep surface water from entering the manhole. Unused ducts shall be plugged and water seepage through ducts in use shall be stopped before the splice is started.

3.3 PULLING CABLES IN DUCTS, MANHOLES AND UTILITY TUNNELS

- A. Medium-voltage cables shall be pulled into ducts and utility tunnels with equipment designed for this purpose, including power-driven winch, cable-feeding flexible tube guide, cable grips, and lubricants. A sufficient number of trained personnel and equipment shall be employed to ensure the careful and proper installation of the cable.
- B. Cable reel shall be set up at the side of the manhole or tunnel hatch opening and above the duct or hatch level, allowing the cable to enter through the opening without reverse bending. Flexible tube guide shall be installed through the opening in a manner that will prevent the cable from rubbing on the edges of any structural member.

- C. Pulling force for a cable grip on lead-sheathed cable shall not exceed manufacturer's recommendation. A dynamometer shall be used in the pulling line to ensure that the pulling force is not exceeded. Pulling force for a nonmetallic-sheathed cable shall not exceed the smaller of 4400 Newton (1,000 pounds) or a value computed from the following equation:

$$TM = 0.008 \times N \times CM$$

Where: TM = maximum allowable pulling tension in Newton pounds

N = number of conductors in the cable

CM = cross-sectional area of each conductor in square millimeter circular mils.

- D. Cable shall be unreeled from the top of the reel. Payout shall be carefully controlled. Cable to be pulled shall be attached through a swivel to the main pulling wire by means of a pulling eye.
- E. Woven-wire cable grips shall be used to grip the cable end when pulling small cables and short straight lengths of heavier cables.
- F. Pulling eyes shall be attached to the cable conductors to prevent damage to the cable structure.
- G. Pulling eyes and cable grips shall be used together for nonmetallic sheathed cables to prevent damage to the cable structure.
- H. Cables shall be liberally coated with a suitable cable-pulling lubricant as it enters the tube guide or duct. Grease and oil lubricants shall be used only on lead-sheathed cables. Nonmetallic sheathed cables shall be covered with wire-pulling compounds when required which have no deleterious effects on the cable. Rollers, sheaves, or tube guides around which the cable is pulled shall conform to the minimum bending radius of the cable.
- I. Cables shall be pulled into ducts at a reasonable speed not in excess of maximum permissible pulling tension specified by the cable manufacturer. Cable pulling using a vehicle shall not be permitted. Pulling operations shall be stopped immediately with any indication of binding or obstruction and shall not be resumed until such difficulty is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.
- J. Cable splices made up in manholes or utility tunnels shall be firmly supported on cable racks as indicated. No cable splices shall be pulled in ducts. Cable ends shall overlap at the ends of a section to provide sufficient undamaged cable for splicing. Cables to be spliced in

manholes or utility tunnels shall overlap the centerline of the proposed joint by not less than 600 mm (2 feet).

- K. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture. Nonleaded cables shall be sealed with rubber tape wrapped down to 75 mm (3 inches) from the cable end. Rubber tape shall be cover-wrapped with polyvinylchloride tape. Lead-Covered cables shall be sealed with wiping metal making a firm bond with the end of the sheath or with a disk of lead fitted over the end and wiped to the sheath.

3.4 INSTALLATION, SPLICES AND TERMINATIONS

- A. Install the materials as recommended by their manufacturer including special precautions pertaining to air temperature during installation.
- B. Cross-Linked Polyethylene (XLPE), Ethylene Propylene Rubber and Polyethylene Insulated Cables:
1. Cables rated 5000 volts or less: Install epoxy resin splices and terminations, or pre-molded rubber splices and terminations.
 2. Cables rated more than 5000 volts: Install taped splices and terminations, or pre-molded rubber splices and terminations.
- C. Installation shall be accomplished by qualified personnel trained to accomplish high voltage equipment installations. All instructions of the manufacturer shall be followed in detail.
- D. Splices shall be made in manholes or tunnels except where cable terminations are specifically indicated. Splicing and terminating of cables shall be expedited to minimize exposure and cable deterioration.
- E. Cables shall be terminated in potheads. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones may be used for terminating cables. Potheads shall be provided with adequate means for making external connections to the cable conductors of single or multiple conductor cables; protecting the cable insulation against moisture, oil, or other contaminant; physically protecting and supporting cables, and maintaining the insulation level of the cable.
- F. Pothead terminations shall be field fabricated from termination kits supplied by and in accordance with the pothead manufacturer's recommendations for the type, size, and electrical characteristics of the cable.
- G. Installation shall include built-up or prefabricated heat or cold shrink stress-relief cones at the terminals of all shielded cables and

at the terminals of single-conductor lead-covered cables rated 15 kV and above, ungrounded.

- H. Cable splices shall be field fabricated from splicing kits supplied by and in accordance with cable manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified. Cable splices in manholes shall be located midway between cable racks on walls of manholes and supported with cable arms at approximately the same elevation as the enclosing duct.
- I. Cable splices in the tunnel that are not installed in cable trays shall be installed on cable racks or by other approved methods that will minimize physical stress on the splice connections. Splices shall be supported at approximately the same elevation as the installed cable except where space limitations or existing cable length limitations make this method impractical or impossible.
- J. Universal demountable splices shall be supported in such manner so as to minimize physical stress on the splice connections. Each cable end termination shall be supported using a pair of saddle type supports under the cable end termination and/or cable with a minimum 300 mm (12 inches) and a maximum 750 mm (30 inches) separation between the supports. Cable end termination and cable shall be secured to the supports in such a manner as to prevent movement of termination or cable at the support. Saddle type supports shall be installed on galvanized steel framing channel anchored to the wall or securely fastened to the cable tray or installed by other approved methods.

3.5 INSTALLATION, FIREPROOFING

- A. Cover all power cables located in manholes, handholes and junction boxes with arc proof and fireproof tape.
- B. Apply the tape in a single layer, one-half lapped or as recommended by the manufacturer. Install the tape with the coated side towards the cable and extend it not less than 25 mm (one inch) into each duct.
- C. Secure the tape in place by a random wrap of glass cloth tape.

3.6 FEEDER IDENTIFICATION

In each manhole and pullbox install permanent tags on each circuit's cables and wires to clearly designate their circuit identification and voltage. In manholes the tags shall be the embossed brass type and shall also show the cable type and voltage rating. Position the tags so they will be easy to read after the fireproofing is installed.

3.7 FIELD TESTS FOR HIGH VOLTAGE CABLE**A. New Cable:**

1. Acceptance tests shall be performed on new and service aged PE XLPE, PVC and paper cables in accordance with IEEE 400.2 and as specified herein.
2. Test new cable after installation, splices, and terminations have been made, but before connection to equipment and existing cable.
3. Test equipment, labor and technical personnel shall be provided as necessary to perform the electrical acceptance tests. Arranges shall be made to have tests witnessed by the COTR.

B. Service Age Cable:

1. Maintenance tests shall be performed on service-aged cable interconnected to new cable. See test voltages below.
2. After new cable test and connection to an existing cable, test the interconnected cable. Disconnect cable from all equipment that might be damaged by the test voltages.

C. Dielectric Absorption Test: Both new and service aged power cable shall be completely isolated from extraneous electrical connections at cable terminations and joints. Safety precautions shall be observed. Each cable shall be given a full dielectric - absorption test with a 5000v insulation resistance test set. Test shall be applied for a long enough time to charge the cable. Readings shall be recorded every 15 seconds during the first 3 minutes of test and at 1 minute intervals thereafter. Test shall continue until three equal readings 1 minute apart are obtained. Minimum readings shall be 200 megohms at an ambient temperature 20 degrees C (68 degrees F). Readings taken at other temperatures shall be corrected accordingly.

D. High Potential Test: High potential test shall not be applied to the XLPE new or service aged cables. All other cables shall be subjected to the test but only upon successful dielectric absorption test.

1. Leakage current test shall be by high potential dc step voltage method.
2. High potential test shall measure the leakage current from each conductor to the insulation shield. Use corona shields, guard rings, taping, mason jars, or plastic bags to prevent corona current from influencing the readings. Unprepared cable shield ends shall be trimmed back 25 mm (1 inch) or more for each 10 kV of test voltage. Upon the successful completion of the high potential test on new and

service aged PE CCLP, PC PVC cables a second dielectric test will be run on the HV cable system to ensure the cables have not been damaged by the hi-pot test

E. Safety Precautions:

1. Exercise suitable and adequate safety measures prior to, during, and after the high potential tests, including placing warning signs and preventing people and equipment from being exposed to the test voltages.

F. Test Voltages:

1. New shielded EPR and CCLP cable dc test voltages shall be as follows:

Rated Circuit Voltage Phase-to-Phase Volt	Wire Size AWG or MCM	Test Voltage KV
2001-5000	8-1000	25
5001-8000	6-1000	35
8001-15000	2-1000	65
15001-25001	1-1000	100
25001-28000	1-1000	-
28001-35000	1/0-1000	-

2. Existing cable of all types interconnected to a new cable shall be tested at 1.7 times the existing cable rated voltage (maintenance test).

G. High Potential Test Method:

1. Apply voltage in approximately 8 to 10 equal steps.
2. Raise the voltage slowly between steps.
3. At the end of each step, allow the charging currents to decay, and time the interval of decay.
4. Read the leakage current and plot a curve of leakage currents versus test voltage on graph paper as the test progresses. Read the leakage current at the same time interval for each voltage step.
5. Stop the test if leakage currents increase excessively or a "knee" appears in the curve before maximum test voltage is reached.
 - a. For new cable, repair or replace the cable and repeat the test.
 - b. For existing cable interconnected to new cable, notify the COTR for further instructions.
6. Upon reaching maximum test voltage, hold the voltage for five minutes. Read the leakage current at 30 second intervals and plot a

curve of leakage current versus time on the same graph paper as the step voltage curve. Stop the test if leakage current starts to rise, or decreases and again starts to rise. Leakage current should decrease and stabilize for good cable.

7. Terminate test and allow sufficient discharge time before testing the next conductor.
- H. Test Data: Test data shall be recorded and shall include identification of cable and location, megohm readings versus time, leakage current readings versus time, and cable temperature versus time.
- I. Final Acceptance: Final acceptance shall depend upon the satisfactory performance of the cable under test. No cable shall be energized until recorded test data have been approved by the COTR. Final test reports shall be provided to the COTR. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Report" Forward to the COTR for inclusion in the Maintenance Database.
- J. Radiographic Tests: Radiographic tests shall be performed on all potheads at the discretion of the COTR to determine if voids exist in the pothead. Unacceptable terminations shall be reworked at no additional expense to the Government.
- K. The contractor shall furnish the instruments, materials and labor for these tests.

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SECTION 26 05 21**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW)****PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation, and connection of the low voltage power and lighting wiring.

1.2 RELATED WORK

- A. Excavation and backfill for cables that are installed in conduit:
Section 31 20 00, EARTH MOVING.
- B. Sealing around penetrations to maintain the integrity of time rated construction: Section 07 84 00, FIRESTOPPING.
- C. General electrical requirements that are common to more than one section in Division 26: Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- D. Conduits for cables and wiring: Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- E. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents: Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1.3 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:
 - 1. Manufacturer's Literature and Data: Showing each cable type and rating.
 - 2. Certificates: Two weeks prior to final inspection, deliver to the COTR four copies of the certification that the material is in accordance with the drawings and specifications and has been properly installed.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by the basic designation only.
- B. American Society of Testing Material (ASTM):
D2301-04.....Standard Specification for Vinyl Chloride
Plastic Pressure Sensitive Electrical Insulating
Tape
- C. Federal Specifications (Fed. Spec.):

A-A-59544-00.....Cable and Wire, Electrical (Power, Fixed
Installation)

C. National Fire Protection Association (NFPA):

70-05.....National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

44-02.....Thermoset-Insulated Wires and Cables

83-03.....Thermoplastic-Insulated Wires and Cables

467-01.....Electrical Grounding and Bonding Equipment

486A-01.....Wire Connectors and Soldering Lugs for Use with
Copper Conductors

486C-02.....Splicing Wire Connectors

486D-02.....Insulated Wire Connector Systems for Underground
Use or in Damp or Wet Locations

486E-00.....Equipment Wiring Terminals for Use with Aluminum
and/or Copper Conductors

493-01.....Thermoplastic-Insulated Underground Feeder and
Branch Circuit Cable

514B-02.....Fittings for Cable and Conduit

1479-03.....Fire Tests of Through-Penetration Fire Stops

PART 2 - PRODUCTS

2.1 CABLE AND WIRE (POWER AND LIGHTING)

A. Cable and Wire shall be in accordance with Fed. Spec. A-A-59544, except as hereinafter specified.

B. Single Conductor:

1. Shall be annealed copper.

2. Shall be stranded for sizes No. 8 AWG and larger, solid for sizes No. 10 AWG and smaller.

3. Shall be minimum size No. 12 AWG, except where smaller sizes are allowed herein.

C. Insulation:

1. THW, XHHW, or dual rated THHN-THWN shall be in accordance with UL 44, and 83.

2. Direct burial: UF or USE shall be in accordance with UL 493.

3. Isolated power system wiring: Type XHHW with a dielectric constant of 3.5 or less.

D. Color Code:

1. Secondary service, feeder and branch circuit conductors shall be color coded as follows:

208/120 volt	Phase	480/277 volt
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Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

- a. The lighting circuit "switch legs" and 3-way switch "traveling wires" shall have color coding unique and distinct (i.e. pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC. Field coordinate for a final color coding with the COTR.
2. Use solid color compound or solid color coating for No. 12 AWG and No. 10 AWG branch circuit conductors and neutral sizes.
3. Phase conductors No. 8 AWG and larger shall be color-coded using one of the following methods:
 - a. Solid color compound or solid color coating.
 - b. Stripes, bands, or hash marks of color specified above.
 - c. Color as specified using 19 mm (3/4 inch) wide tape. Apply tape in half overlapping turns for a minimum of 75 mm (three inches) for terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable stating size and insulation type.
4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.
5. Color code for isolated power system wiring shall be in accordance with the NEC.

2.2 SPLICES AND JOINTS

- A. In accordance with UL 486A, C, D, E and NEC.
- B. Branch circuits (No. 10 AWG and smaller):
 1. Connectors: Solderless, screw-on, reusable pressure cable type, 600 volt, 105 degree C with integral insulation, approved for copper and aluminum conductors.
 2. The integral insulator shall have a skirt to completely cover the stripped wires.
 3. The number, size, and combination of conductors, as listed on the manufacturers packaging shall be strictly complied with.

C. Feeder Circuits:

1. Connectors shall be indent, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material.
2. Field installed compression connectors for cable sizes 250 kcmil and larger shall have not less than two clamping elements or compression indents per wire.
3. Insulate splices and joints with materials approved for the particular use, location, voltage, and temperature. Insulate with not less than that of the conductor level that is being joined.
4. Plastic electrical insulating tape: ASTM D2304 shall apply, flame retardant, cold and weather resistant.

2.3 CONTROL WIRING

- A. Unless otherwise specified in other sections of these specifications, control wiring shall be as specified for power and lighting wiring, except the minimum size shall be not less than No. 14 AWG.
- B. Control wiring shall be large enough so that the voltage drop under inrush conditions does not adversely affect operation of the controls.

2.4 WIRE LUBRICATING COMPOUND

- A. Suitable for the wire insulation and conduit it is used with, and shall not harden or become adhesive.
- B. Shall not be used on wire for isolated type electrical power systems.

2.5 FIREPROOFING TAPE

- A. The tape shall consist of a flexible, conformable fabric of organic composition coated one side with flame-retardant elastomer.
- B. The tape shall be self-extinguishing and shall not support combustion. It shall be arc-proof and fireproof.
- C. The tape shall not deteriorate when subjected to water, gases, salt water, sewage, or fungus and be resistant to sunlight and ultraviolet light.
- D. The finished application shall withstand a 200-ampere arc for not less than 30 seconds.
- E. Securing tape: Glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (3/4 inch) wide.

2.6 WARNING TAPE

- A. The tape shall be standard, 76 mm (3 inch) wide, 4-Mil polyethylene detectable type.
- B. The tape shall be red with black letters indicating "CAUTION BURIED ELECTRIC LINE BELOW".

PART 3 - EXECUTION**3.1 INSTALLATION, GENERAL**

- A. Install in accordance with the NEC, and as specified.
- B. Install all wiring in raceway systems, except where direct burial or HCF Type AC cables are used.
- C. Splice cables and wires only in outlet boxes, junction boxes, pull boxes, manholes, or handholes.
- D. Wires of different systems (i.e. 120V, 277V) shall not be installed in the same conduit or junction box system.
- E. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.
- F. For panelboards, cabinets, wireways, switches, and equipment assemblies, neatly form, train, and tie the cables in individual circuits.
- G. Seal cable and wire entering a building from underground, between the wire and conduit where the cable exits the conduit, with a non-hardening approved compound.
- H. Wire Pulling:
 - 1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables.
 - 2. Use ropes made of nonmetallic material for pulling feeders.
 - 3. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors, as approved by the COTR.
 - 4. Pull in multiple cables together in a single conduit.
- I. No more than (3) single-phase branch circuits shall be installed in any one conduit.
- J. The wires shall be derated in accordance with NEC Article 310. Neutral wires, under conditions defined by the NEC, shall be considered current-carrying conductors.

3.2 INSTALLATION IN MANHOLES

- A. Install and support cables in manholes on the steel racks with porcelain or equal insulators. Train the cables around the manhole walls, but do not bend to a radius less than six times the overall cable diameter.

3.3 SPLICE INSTALLATION

- A. Splices and terminations shall be mechanically and electrically secure.
- B. Where the Government determines that unsatisfactory splices or terminations have been installed, remove the devices and install approved devices at no additional cost to the Government.

3.4 CONTROL AND SIGNAL WIRING INSTALLATION

- A. Unless otherwise specified in other sections, install wiring and connect to equipment/devices to perform the required functions as shown and specified.
- B. Except where otherwise required, install a separate power supply circuit for each system so that malfunctions in any system will not affect other systems.
- C. Where separate power supply circuits are not shown, connect the systems to the nearest panelboards of suitable voltages, which are intended to supply such systems and have suitable spare circuit breakers or space for installation.
- D. Install a red warning indicator on the handle of the branch circuit breaker for the power supply circuit for each system to prevent accidental de-energizing of the systems.
- E. System voltages shall be 120 volts or lower where shown on the drawings or as required by the NEC.

3.5 CONTROL AND SIGNAL SYSTEM IDENTIFICATION

- A. Install a permanent wire marker on each wire at each termination.
- B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
- C. Wire markers shall retain their markings after cleaning.
- D. In each manhole and handhole, install embossed brass tags to identify the system served and function.

3.6 FEEDER IDENTIFICATION

- A. In each interior pulbox and junction box, install metal tags on each circuit cables and wires to clearly designate their circuit identification and voltage.
- B. In each manhole and handhole, provide tags of the embossed brass type, showing the cable type and voltage rating. Attach the tags to the cables with slip-free plastic cable lacing units.

3.7 EXISTING WIRING

Unless specifically indicated on the plans, existing wiring shall not be reused for the new installation. Only wiring that conforms to the specifications and applicable codes may be reused. If existing wiring does not meet these requirements, existing wiring may not be reused and new wires shall be installed.

3.8 FIELD TESTING

- A. Feeders and branch circuits shall have their insulation tested after installation and before connection to utilization devices such as fixtures, motors, or appliances.

- B. Tests shall be performed by megger and conductors shall test free from short-circuits and grounds.
- C. Test conductor phase-to-phase and phase-to-ground.
- D. The Contractor shall furnish the instruments, materials, and labor for these tests.

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SECTION 26 05 26**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. This section specifies general grounding and bonding requirements of electrical equipment operations and to provide a low impedance path for possible ground fault currents.
- B. "Grounding electrode system" refers to all electrodes required by NEC, as well as including made, supplementary, lightning protection system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low Voltage power and lighting wiring.
- C. Section 26 41 00, FACILITY LIGHTNING PROTECTION: Requirements for a lightning protection system.

1.3 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.
- C. Test Reports: Provide certified test reports of ground resistance.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - 1. Certification that the materials and installation is in accordance with the drawings and specifications.
 - 2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

1.4 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

A. American Society for Testing and Materials (ASTM):

B1-2001.....Standard Specification for Hard-Drawn Copper
Wire

B8-2004.....Standard Specification for Concentric-Lay-
Stranded Copper Conductors, Hard, Medium-Hard,
or Soft

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

81-1983.....IEEE Guide for Measuring Earth Resistivity,
Ground Impedance, and Earth Surface Potentials
of a Ground System

C. National Fire Protection Association (NFPA):

70-2005.....National Electrical Code (NEC)

99-2005.....Health Care Facilities

D. Underwriters Laboratories, Inc. (UL):

44-2005Thermoset-Insulated Wires and Cables

83-2003Thermoplastic-Insulated Wires and Cables

467-2004Grounding and Bonding Equipment

486A-486B-2003Wire Connectors

PART 2 - PRODUCTS**2.1 GROUNDING AND BONDING CONDUCTORS**

- A. Equipment grounding conductors shall be UL 83 insulated stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes 25 mm² (4 AWG) and larger shall be permitted to be identified per NEC.
- B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be ASTM B1 solid bare copper wire.
- C. Isolated Power System: Type XHHW-2 insulation with a dielectric constant of 3.5 or less.
- D. Electrical System Grounding: Conductor sizes shall not be less than what is shown on the drawings and not less than required by the NEC, whichever is greater.

2.2 GROUND RODS

- A. Copper clad steel, 19 mm (3/4-inch) diameter by 3000 mm (10 feet) long, conforming to UL 467.
- B. Quantity of rods shall be as required to obtain the specified ground resistance.

2.3 SPLICES AND TERMINATION COMPONENTS

Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.4 GROUND CONNECTIONS

- A. Below Grade: Exothermic-welded type connectors.
- B. Above Grade:
 - 1. Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lockwashers.
 - 2. Ground Busbars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.
 - 3. Rack and Cabinet Ground Bars: one-hole compression-type lugs using zinc-plated or copper alloy fasteners.

2.5 EQUIPMENT RACK AND CABINET GROUND BARS

Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks with minimum dimensions of 4 mm thick by 19 mm wide (3/8 inch x 3/4 inch).

2.6 GROUND TERMINAL BLOCKS

At any equipment mounting location (e.g. backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

2.7 SPLICE CASE GROUND ACCESSORIES

Splice case grounding and bonding accessories shall be supplied by the splice case manufacturer when available. Otherwise, use 16 mm² (6 AWG) insulated ground wire with shield bonding connectors.

PART 3 - EXECUTION**3.1 GENERAL**

- A. Ground in accordance with the NEC, as shown on drawings, and as hereinafter specified.
- B. System Grounding:
 - 1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
 - 2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

3. Isolation transformers and isolated power systems shall not be system grounded.

- C. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.
- D. Special Grounding: For patient care area electrical power system grounding, conform to NFPA 99, and NEC.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

Make grounding connections, which are buried or otherwise normally inaccessible (except connections for which periodic testing access is required) by exothermic weld.

3.3 MEDIUM-VOLTAGE EQUIPMENT AND CIRCUITS

- A. Switchgear: Provide a bare grounding electrode conductor from the switchgear ground bus to the grounding electrode system.
- B. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing medium or high voltage conductors, sized per NEC except that minimum size shall be 25 mm² (2 AWG). Bond the equipment grounding conductors to the switchgear ground bus, to all manhole hardware and ground rods, to the cable shielding grounding provisions of medium or high voltage cable splices and terminations, and equipment enclosures.
- C. Lightning Arresters: Connect lightning arresters to the equipment ground bus or ground rods as applicable.
- D. Metallic Conduit: Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a bare grounding conductor to the equipment ground bus.

3.4 SECONDARY EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
- B. Metallic Piping, Building Steel, and Supplemental Electrode(s):
 - 1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water and gas pipe systems, building steel, and supplemental or made electrodes. Jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to UL 467.

2. Provide a supplemental ground electrode and bond to the grounding electrode system.
- C. Service Disconnect (Separate Individual Enclosure): Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors.
- D. Switchgear, Switchboards, Unit Substations, and Motor Control Centers:
1. Connect the various feeder equipment grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
 2. For service entrance equipment, connect the grounding electrode conductor to the ground bus.
 3. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and grounding conductor to the equipment ground bus.
- E. Transformers:
1. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the nearest component of the grounding electrode system.
- F. Conduit Systems:
1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
 2. Non-metallic conduit systems shall contain an equipment grounding conductor, except that non-metallic feeder conduits which carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment need not contain an equipment grounding conductor.
 3. Conduit containing only a grounding conductor, and which is provided for mechanical protection of the conductor, shall be bonded to that conductor at the entrance and exit from the conduit.
- G. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders and power and lighting branch circuits.
- H. Boxes, Cabinets, Enclosures, and Panelboards:
1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes.
 2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

- 3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.
- I. Motors and Starters: Provide lugs in motor terminal box and starter housing or motor control center compartment to terminate equipment grounding conductors.
- J. Receptacles shall not be grounded through their mounting screws. Ground with a jumper from the receptacle green ground terminal to the device box ground screw and the branch circuit equipment grounding conductor.
- K. Ground lighting fixtures to the equipment grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- L. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.
- M. Raised Floors: Provide bonding of all raised floor components.
- N. Panelboard Bonding: The equipment grounding terminal buses of the normal and essential branch circuit panelboards serving the same individual patient vicinity shall be bonded together with an insulated continuous copper conductor not less than 16 mm² (10 AWG). These conductors shall be installed in rigid metal conduit.

3.5 CORROSION INHIBITORS

When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.6 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the building to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.
- B. In operating rooms and at intensive care and coronary care type beds, bond the gases and suction piping, at the outlets, directly to the room or patient ground bus.

3.7 LIGHTNING PROTECTION SYSTEM

- A. Bond the lightning protection system to the electrical grounding electrode system.

3.8 ELECTRICAL ROOM GROUNDING

- A. Building Earth Ground Busbars: Provide ground busbar hardware at each

electrical room and connect to pigtail extensions of the building grounding ring.

3.9 WIREWAY GROUNDING

A. Ground and Bond Metallic Wireway Systems as follows:

1. Bond the metallic structures of wireway to provide 100 percent electrical continuity throughout the wireway system by connecting a 16 mm² (6 AWG) bonding jumper at all intermediate metallic enclosures and across all section junctions.
2. Install insulated 16 mm² (6 AWG) bonding jumpers between the wireway system bonded as required in paragraph 1 above, and the closest building ground at each end and approximately every 16 meters (50 feet).
3. Use insulated 16 mm² (6 AWG) bonding jumpers to ground or bond metallic wireway at each end at all intermediate metallic enclosures and cross all section junctions.
4. Use insulated 16 mm² (6 AWG) bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 meters.

3.10 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Government. Final tests shall assure that this requirement is met.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Below-grade connections shall be visually inspected by the COTR prior to backfilling. The Contractor shall notify the COTR 24 hours before the connections are ready for inspection.

3.11 GROUND ROD INSTALLATION

- A. Drive each rod vertically in the earth, not less than 3000 mm (10 feet) in depth.
- B. Where permanently concealed ground connections are required, make the connections by the exothermic process to form solid metal joints. Make accessible ground connections with mechanical pressure type ground connectors.

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SECTION 26 05 33**RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.
- B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

- A. Bedding of conduits: Section 31 20 00, EARTH MOVING.
- B. Mounting board for telephone closets: Section 06 10 00, ROUGH CARPENTRY.
- C. Sealing around penetrations to maintain the integrity of fire rated construction: Section 07 84 00, FIRESTOPPING.
- D. Fabrications for the deflection of water away from the building envelope at penetrations: Section 07 60 00, FLASHING AND SHEET METAL.
- E. Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building: Section 07 92 00, JOINT SEALANTS.
- F. Identification and painting of conduit and other devices: Section 09 91 00, PAINTING.
- G. General electrical requirements and items that is common to more than one section of Division 26: Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- H. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents: Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1.3 SUBMITTALS

In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:

- A. Shop Drawings:
 - 1. Size and location of main feeders;
 - 2. Size and location of panels and pull boxes
 - 3. Layout of required conduit penetrations through structural elements.
 - 4. The specific item proposed and its area of application shall be identified on the catalog cuts.

- B. Certification: Prior to final inspection, deliver to the COTR four copies of the certification that the material is in accordance with the drawings and specifications and has been properly installed.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
70-05.....National Electrical Code (NEC)
- C. Underwriters Laboratories, Inc. (UL):
1-03.....Flexible Metal Conduit
5-01.....Surface Metal Raceway and Fittings
6-03.....Rigid Metal Conduit
50-03.....Enclosures for Electrical Equipment
360-03.....Liquid-Tight Flexible Steel Conduit
467-01.....Grounding and Bonding Equipment
514A-01.....Metallic Outlet Boxes
514B-02.....Fittings for Cable and Conduit
514C-05.....Nonmetallic Outlet Boxes, Flush-Device Boxes and
Covers
651-02.....Schedule 40 and 80 Rigid PVC Conduit
651A-03.....Type EB and A Rigid PVC Conduit and HDPE Conduit
797-03.....Electrical Metallic Tubing
1242-00.....Intermediate Metal Conduit
- D. National Electrical Manufacturers Association (NEMA):
TC-3-04.....PVC Fittings for Use with Rigid PVC Conduit and
Tubing
FB1-03.....Fittings, Cast Metal Boxes and Conduit Bodies
for Conduit, Electrical Metallic Tubing and
Cable

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Conduit Size: In accordance with the NEC, but not less than 13 mm (1/2 inch) unless otherwise shown. Where permitted by the NEC, 13 mm (1/2 inch) flexible conduit may be used for tap connections to recessed lighting fixtures.
- B. Conduit:
1. Rigid galvanized steel: Shall Conform to UL 6, ANSI C80.1.
 2. Rigid aluminum: Shall Conform to UL 6A, ANSI C80.5.

3. Rigid intermediate steel conduit (IMC): Shall Conform to UL 1242, ANSI C80.6.
4. Electrical metallic tubing (EMT): Shall Conform to UL 797, ANSI C80.3. Maximum size not to exceed 105 mm (4 inch) and shall be permitted only with cable rated 600 volts or less.
5. Flexible galvanized steel conduit: Shall Conform to UL 1.
6. Liquid-tight flexible metal conduit: Shall Conform to UL 360.
7. Direct burial plastic conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high density polyethylene (PE).
8. Surface metal raceway: Shall Conform to UL 5.

C. Conduit Fittings:

1. Rigid steel and IMC conduit fittings:
 - a. Fittings shall meet the requirements of UL 514B and ANSI/ NEMA FB1.
 - a. Standard threaded couplings, locknuts, bushings, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
 - b. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
 - c. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - d. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
 - e. Sealing fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
2. Rigid aluminum conduit fittings:
 - a. Standard threaded couplings, locknuts, bushings, and elbows: Malleable iron, steel or aluminum alloy materials; Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.

- b. Locknuts and bushings: As specified for rigid steel and IMC conduit.
- c. Set screw fittings: Not permitted for use with aluminum conduit.
- 3. Electrical metallic tubing fittings:
 - a. Fittings shall meet the requirements of UL 514B and ANSI/ NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Couplings and connectors: Concrete tight and rain tight, with connectors having insulated throats. Use gland and ring compression type couplings and connectors for conduit sizes 50 mm (2 inches) and smaller. Use set screw type couplings with four set screws each for conduit sizes over 50 mm (2 inches). Use set screws of case-hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.
 - d. Indent type connectors or couplings are prohibited.
 - e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
- 4. Flexible steel conduit fittings:
 - a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
 - b. Clamp type, with insulated throat.
- 5. Liquid-tight flexible metal conduit fittings:
 - a. Fittings shall meet the requirements of UL 514B and ANSI/ NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.
- 6. Direct burial plastic conduit fittings:
 - a. Fittings shall meet the requirements of UL 514C and NEMA TC3.
 - b. As recommended by the conduit manufacturer.
- 7. Surface metal raceway fittings: As recommended by the raceway manufacturer.
- 8. Expansion and deflection couplings:
 - a. Conform to UL 467 and UL 514B.
 - b. Accommodate, 19 mm (0.75 inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.

- c. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL 467, and the NEC code tables for ground conductors.
 - d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material with stainless steel jacket clamps.
- D. Conduit Supports:
- 1. Parts and hardware: Zinc-coat or provide equivalent corrosion protection.
 - 2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
 - 3. Multiple conduit (trapeze) hangers: Not less than 38 mm by 38 mm (1-1/2 by 1-1/2 inch), 12 gage steel, cold formed, lipped channels; with not less than 9 mm (3/8 inch) diameter steel hanger rods.
 - 4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.
- E. Outlet, Junction, and Pull Boxes:
- 1. UL-50 and UL-514A.
 - 2. Cast metal where required by the NEC or shown, and equipped with rustproof boxes.
 - 3. Sheet metal boxes: Galvanized steel, except where otherwise shown.
 - 4. Flush mounted wall or ceiling boxes shall be installed with raised covers so that front face of raised cover is flush with the wall. Surface mounted wall or ceiling boxes shall be installed with surface style flat or raised covers.
- F. Wireways: Equip with hinged covers, except where removable covers are shown.
- G. Warning Tape: Standard, 4-Mil polyethylene 76 mm (3 inch) wide tape detectable type, red with black letters, and imprinted with "CAUTION BURIED ELECTRIC LINE BELOW".

PART 3 - EXECUTION

3.1 PENETRATIONS

- A. Cutting or Holes:
- 1. Locate holes in advance where they are proposed in the structural sections such as ribs or beams. Obtain the approval of the COTR prior to drilling through structural sections.
 - 2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammer, impact

- electric, hand or manual hammer type drills are not allowed, except where permitted by the COTR as required by limited working space.
- B. Fire Stop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING, with rock wool fiber or silicone foam sealant only. Completely fill and seal clearances between raceways and openings with the fire stop material.
- C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal clearances around the conduit and make watertight as specified in Section 07 92 00, JOINT SEALANTS.

3.2 INSTALLATION, GENERAL

- A. In accordance with UL, NEC, as shown, and as hereinafter specified.
- B. Essential (Emergency) raceway systems shall be entirely independent of other raceway systems, except where specifically "accepted" by NEC Article 517.
- C. Install conduit as follows:
1. In complete runs before pulling in cables or wires.
 2. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new undamaged material.
 3. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
 4. Cut square with a hacksaw, ream, remove burrs, and draw up tight.
 5. Mechanically and electrically continuous.
 6. Independently support conduit at 8'0" on center. Do not use other supports i.e., (suspended ceilings, suspended ceiling supporting members, lighting fixtures, conduits, mechanical piping, or mechanical ducts).
 7. Support within 300 mm (1 foot) of changes of direction, and within 300 mm (1 foot) of each enclosure to which connected.
 8. Close ends of empty conduit with plugs or caps at the rough-in stage to prevent entry of debris, until wires are pulled in.
 9. Conduit installations under fume and vent hoods are prohibited.
 10. Secure conduits to cabinets, junction boxes, pull boxes and outlet boxes with bonding type locknuts. For rigid and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.

11. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL.
12. Do not use aluminum conduits in wet locations.
13. Unless otherwise indicated on the drawings or specified herein, all conduits shall be installed concealed within finished walls, floors and ceilings.

D. Conduit Bends:

1. Make bends with standard conduit bending machines.
2. Conduit hickey may be used for slight offsets, and for straightening stubbed out conduits.
3. Bending of conduits with a pipe tee or vise is prohibited.

E. Layout and Homeruns:

1. Install conduit with wiring, including homeruns, as shown.
2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted approved by the COTR.

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, Only.
2. Align and run conduit in direct lines.
3. Install conduit through concrete beams only when the following occurs:
 - a. Where shown on the structural drawings.
 - b. As approved by the COTR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
4. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.
 - a. Conduit outside diameter larger than 1/3 of the slab thickness is prohibited.
 - b. Space between conduits in slabs: Approximately six conduit diameters apart, except one conduit diameter at conduit crossings.
 - c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (3/4 inch) of concrete around the conduits.
5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to insure low resistance ground continuity through the conduits. Tightening set screws with pliers is prohibited.

B. Furred or Suspended Ceilings and in Walls:

1. Conduit for conductors above 600 volts:
 - a. Rigid steel or rigid aluminum.
 - b. Aluminum conduit mixed indiscriminately with other types in the same system is prohibited.
2. Conduit for conductors 600 volts and below:
 - a. Rigid steel, IMC, rigid aluminum, or EMT. Different type conduits mixed indiscriminately in the same system is prohibited.
3. Align and run conduit parallel or perpendicular to the building lines.
4. Connect recessed lighting fixtures to conduit runs with maximum 1800 mm (six feet) of flexible metal conduit extending from a junction box to the fixture.
5. Tightening set screws with pliers is prohibited.

3.4 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on the drawings, exposed conduit is only permitted in mechanical and electrical rooms.
- B. Conduit for conductors above 600 volts:
 1. Rigid steel or rigid aluminum.
 2. Aluminum conduit mixed indiscriminately with other types in the same system is prohibited.
- C. Conduit for Conductors 600 volts and below:
 1. Rigid steel, IMC, rigid aluminum, or EMT. Different type of conduits mixed indiscriminately in the system is prohibited.
- D. Align and run conduit parallel or perpendicular to the building lines.
- E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
- F. Support horizontal or vertical runs at not over 2400 mm (eight foot) intervals.
- G. Surface metal raceways: Use only where shown.
- H. Painting:
 1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
 2. Paint all conduits containing cables rated over 600 volts safety orange. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color. In addition, paint legends, using 50 mm (two inch) high black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 6000 mm (20 foot) intervals in between.

3.5 DIRECT BURIAL INSTALLATION

- A. Exterior routing of Lighting Systems and Other Branch circuits (600 Volt and Less, and 1500 mm (5 feet) from the buildings):

1. Conduit: Thick wall PVC or high density PE, unless otherwise shown.
 2. Mark conduit at uniform intervals to show the kind of material, direct burial type, and the UL approval label.
 3. Install conduit fittings and terminations as recommended by the conduit manufacturer.
 4. Tops of conduits shall be as follows unless otherwise shown:
 - a. Not less than 600 mm (24 inches) below finished grade.
 - b. Not less than 750 mm (30 inches) below road and other paved surfaces.
 5. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.
 6. Excavation for conduit bedding and back-filling of trenches is specified in Section 31 20 00, EARTH MOVING.
 - a. Cut the trenches neatly and uniformly.
 - b. Do not kink the conduits.
 7. Seal conduits, including spare conduits, at building entrances and at outdoor terminations for equipment with a suitable compound that prevents the entrance of moisture and gases.
 8. Where metal conduit is shown, install threaded heavy wall rigid steel galvanized conduit or type A20 rigid steel galvanized conduit coated with .5 mm (20 mil) bonded PVC, or rigid steel or IMC, PVC coated or standard coated with bituminous asphaltic compound.
 9. Warning tape shall be continuously placed 300 mm (12 inches) above conduits or electric lines.
- B. Exterior routing of lighting systems and other branch circuits (600 volts and less-under buildings slab on grade to 1500 mm (5 feet) from the building):
1. Pre-coated rigid galvanized steel conduit in accordance with the requirements of Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.6 HAZARDOUS LOCATIONS

- A. Use rigid steel conduit only, notwithstanding requirements otherwise specified in this or other sections of these specifications.
- B. Install UL approved sealing fittings, that prevent passage of explosive vapors, in hazardous areas equipped with explosive proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.7 WET OR DAMP LOCATIONS

- A. Unless otherwise shown, use rigid steel conduits.
- B. Provide sealing fittings, to prevent passage of water vapor, where conduits pass from warm to cold locations, i.e., (refrigerated spaces,

constant temperature rooms, air conditioned spaces building exterior walls, roofs) or similar spaces.

- C. Unless otherwise shown, use rigid steel or IMC conduit within 1500 mm (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers. Conduit shall include an outer factory coating of .5 mm (20 mil) bonded PVC or field coat with asphaltum before installation. After installation, completely coat damaged areas of coating.

3.8 MOTORS AND VIBRATING EQUIPMENT

- A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.
- B. Provide liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside (air stream) of HVAC units, and locations subject to seepage or dripping of oil, grease or water. Provide a green ground wire with flexible metal conduit.

3.9 EXPANSION JOINTS

- A. Conduits 75 mm (3 inches) and larger, that are secured to the building structure on opposite sides of a building expansion joint, require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
- B. Provide conduits smaller than 75 mm (3 inches) with junction boxes on both sides of the expansion joint. Connect conduits to junction boxes with sufficient slack of flexible conduit to produce 125 mm (5 inch) vertical drop midway between the ends. Flexible conduit shall have a copper green ground bonding jumper installed. In lieu of this flexible conduit, expansion and deflection couplings as specified above for 375 mm (15 inches) and larger conduits are acceptable.
- C. Install expansion and deflection couplings where shown.

3.10 CONDUIT SUPPORTS, INSTALLATION

- A. Safe working load shall not exceed 1/4 of proof test load of fastening devices.
- B. Use pipe straps or individual conduit hangers for supporting individual conduits. Maximum distance between supports is 2.5 m (8 foot) on center.
- C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and 90 kg (200 pounds). Attach each conduit with U-bolts or other approved fasteners.

- D. Support conduit independently of junction boxes, pull boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.
- E. Fasteners and Supports in Solid Masonry and Concrete:
 - 1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
 - 2. Existing Construction:
 - a. Steel expansion anchors not less than 6 mm (1/4 inch) bolt size and not less than 28 mm (1-1/8 inch) embedment.
 - b. Power set fasteners not less than 6 mm (1/4 inch) diameter with depth of penetration not less than 75 mm (3 inches).
 - c. Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.
- F. Hollow Masonry: Toggle bolts are permitted.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.
- K. Spring steel type supports or fasteners are prohibited for all uses except: Horizontal and vertical supports/fasteners within walls.
- L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION

- A. Boxes for Concealed Conduits:
 - 1. Flush mounted.
 - 2. Provide raised covers for boxes to suit the wall or ceiling, construction and finish.
- B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling in operations.
- C. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
- D. Outlet boxes in the same wall mounted back-to-back are prohibited. A minimum 600 mm (24 inch), center-to-center lateral spacing shall be maintained between boxes.)

- E. Minimum size of outlet boxes for ground fault interrupter (GFI) receptacles is 100 mm (4 inches) square by 55 mm (2-1/8 inches) deep, with device covers for the wall material and thickness involved.
- F. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1".
- G. On all Branch Circuit junction box covers, identify the circuits with black marker.

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SECTION 26 05 41**UNDERGROUND ELECTRICAL CONSTRUCTION****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. This section specifies the furnishing, installation and connection of manholes, handholes and ducts to form a complete underground raceway system.
- B. "Duct" and "conduit", and "rigid metal conduit" and "rigid steel conduit" are used interchangeably in this specification and have the same meaning.

1.2 RELATED WORK

- A. Section 31 20 00, EARTH MOVING: Trenching, backfill and compaction.
- B. Section 05 50 00, METAL FABRICATIONS: Ladders.
- C. Section 07 92 00, JOINT SEALANTS: Sealing of conduit penetrations.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings and boxes for raceway systems.
- F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include manholes, handholes, duct materials, and hardware. Proposed deviations from details on the drawings shall be clearly marked on the submittals.
- If necessary to locate manholes or handholes at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit four copies to the COTR for approval prior to construction.
- 3. Reinforcement shop drawings for precast manholes prepared in accordance with ACI-SP-66.

4. Precast manholes and handholes: Submit plans on elevation showing openings, pulling irons cable supports, sump and other details. Also, submit detail drawings and design calculations for approval prior to installation. Submittal shall bear the seal of a registered structural engineer.
- C. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR:
 1. Certification that the materials are in accordance with the drawings and specifications.
 2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

1.4 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

- A. American Concrete Institute (ACI):
 - Building Code Requirements for Structural Concrete
318/318M-2005.....Building Code Requirements for Structural
Concrete & Commentary
 - SP-66-04.....ACI Detailing Manual
- B. American Society for Testing and Materials (ASTM):
 - C478/C478M 2006(b).....Standard Specification for Precast Reinforced
Concrete Manhole Sections
 - C990 REV A 2003Standard Specification for joints concrete
pipe, Manholes and Precast Box using performed
flexible Joint sealants.
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - C2-2002National Electrical Safety Code
- D. National Electrical Manufacturers Association (NEMA):
 - RNI 2005.....Polyvinyl Chloride (PVC) Externally Coated
Galvanized Rigid Steel Conduit and Intermediate
Metal Conduit
 - TC 2 2003.....Electrical Polyvinyl Chloride (PVC) Tubing And
Conduit
 - TC 3-2004.....PVC Fittings for Use With Rigid PVC Conduit And
Tubing

TC 6 & 8 2003.....PVC Plastic Utilities Duct For Underground
Installations

TC 9-2004.....Fittings For PVC Plastic Utilities Duct For
Underground Installation

E. National Fire Protection Association (NFPA):

70 2005.....National Electrical Code (NEC)

F. Underwriters Laboratories, Inc. (UL):

6-2004.....Electrical Rigid Metal Conduit-Steel

467-2004.....Standard for Grounding and Bonding Equipment

651-2005.....Standard for Schedule 40 and 80 Rigid PVC
Conduit and Fittings

651A-2003.....Type EB and A Rigid PVC Conduit and HDPE
Conduit, (RTRC)

651B-2002.....Continuous Length HDPE Conduit

G. U.S. General Services Administration (GSA):

A-A-60005-1998.....Frames, Covers, Gratings, Steps, Sump and Catch
Basin, Manhole

SS-S-210A-1981.....Sealing Compound, Preformed Plastic for
Expansion joints And Pipe Joints

PART 2 - PRODUCTS

2.1 CONCRETE MANHOLES AND HARDWARE

A. Reinforced Concrete: ACI 318, 20MPA (3000 psi) minimum 28-day
compressive strength.

B. Reinforcing Steel: Number 4 minimum.

C. Manhole Hardware:

1. Frames and covers (traffic type):

a. GSA A-A-60005 Type III.

b. Frames: Style A, size 30A.

c. Covers, Type D, size 30A, marked "POWER" or "SIGNAL" as
applicable.

d. Refer to details on plans.

2. Sump frames and gratings:

a. GSA A-A-60005.

b. Frames, Type VII.

c. Gratings, Type I.

d. Refer to details on plans.

3. Pulling Irons: 22 mm (7/8-inch) diameter hot-dipped galvanized steel
bar with exposed triangular shaped opening.

4. Cable supports:

- a. Cable stanchions, hot rolled, heavy duty, hot-dipped galvanized "T" section steel 56 mm (2-1/4 inches) by 6 mm (1/4-inch) in size and punched with 14 holes on 38 mm (1-1/2 inch) centers for attaching cable arms.
- b. Cable arms, 5 mm (3/16-inch) gage, hot rolled, hot-dipped galvanized sheet steel pressed to channel shape. Arms shall be approximately 63 mm (2-1/2 inches) wide and 350 mm (14 inches) long.
- c. Insulators for cable supports, high glazed, wet process porcelain.
- d. Spares: Equip each cable stanchion with two spare cable arms and six spare insulators for future use.
- e. Miscellaneous hardware, hot-dipped galvanized steel.

5. Manhole Ladders:

Manhole Ladders: Aluminum with 400 mm (16 inch) rung spacing, and per the requirements of Section 05 50 00, METAL FABRICATIONS.

6. Manhole Lighting:

- a. Weatherproof NEMA 3 Lighting switch mounted no more than 2 feet from top of ladder and 100 W incandescent light fixtures shall be provided in manhole. Provide dedicated 20mm (3/4 inches) direct buried conduit to nearest electrical panelboard for circuit conductors.

7. Sump Pump: Provide sump pump complete with float switch, weatherproof receptacle and T-rated switch in manhole. Provide dedicated 20mm (3/4 inches) direct buried conduit to nearest electrical panelboard for circuit conductors.

D. Handhole Hardware:

1. Frames and covers configuration as shown on the drawings. Cast the words "Electric" and "Telephone" in the top face of the power and telephone manhole covers respectively.
2. Pulling irons, 22 mm (7/8-inch) diameter galvanized steel bar with exposed triangular shaped opening.
3. Cable supports are not required.

- E. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.

- F. In lieu of poured-in-place manholes and handholes, the Contractor may provide precast units. Units shall comply with ASTM C478, C478M.

1. Size: Plan area and clear height shall be not less than that shown on the drawings for poured-in-place type.
2. Accessories, hardware, and facilities shall be the same as required for poured-in-place type.
3. Assume ground water level 900 mm (3 feet) below ground surface unless a higher water table is shown in the boring logs and adjust design accordingly.
4. Construction:
 - a. Units, precast monolithically or of assembled sections. Base and first riser shall be monolithic.
 - b. Provide tongue-and-groove joints to firmly interlock adjoining components. Seal joints watertight using preformed plastic or rubber materials conforming to ASTM C990 or GSA SS-S-210A. Install sealing material in strict accordance with the sealant manufacturers' printed instructions.
 - c. Provide lifting devices cast into units.
 - d. Identify all structures with manufacturer's name embedded in, or otherwise permanently attached to an interior wall face.
 - e. Provide a sleeve in manhole floors so that a driven ground rod may be installed.

2.2 FIBERGLASS HANDHOLES

Shall be matched die molded of dark green fiberglass with approximate dimensions of 810 mm (32 inches) high, top surface of 1090 by 950 mm (43 by 37½ inches), and top opening of 810 by 660 mm (32 by 26 inches). When buried, the unit shall be capable of supporting an ultimate downward load of 2955 kg (6500 pounds) distributed over a 150 by 150 mm (6 by 6 inch) area imposed anywhere on the cover surface. Unit shall have precut 150 by 150 mm (6 by 6 inches) cable entrance at the center bottom of each side. A fiberglass weatherproof cover with nonskid surface shall be provided for each handhole. Covers shall be capable of being locked into position.

2.3. DUCTS

- A. Number and sizes shall be as shown on drawings.
- B. Ducts (concrete encased):
 1. Plastic Duct:
 - a. UL 651 and 651A Schedule 40 PVC.
 - b. Duct shall be suitable for use with 90 degree C rated conductors.
 2. Conduit Spacers: Prefabricated plastic.

C. Ducts (direct burial):

1. Plastic duct:

- a. NEMA TC2 and TC3
- b. Schedule 40.
- c. Duct shall be suitable for use with 75 degree C rated conductors.

2. Rigid metal conduit, PVC-coated: UL6 and NEMA RN1 galvanized rigid steel, threaded type, coated with PVC sheath bonded to the galvanized exterior surface, nominal 1 mm (0.040 inch) thick.

2.4 GROUNDING

A. Rods: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS and UL 467

B. Ground Wire: Stranded bare copper 16 mm² (6 AWG) minimum.

2.5 WARNING TAPE

Standard 4-mil polyethylene 76 mm (3 inch) wide tape, detectable type, red with black letters, imprinted with "CAUTION BURIED ELECTRIC CABLE BELOW".

2.6 PULL ROPE

Plastic with 890N (200 pound) minimum tensile strength.

PART 3 - EXECUTION

3.1 MANHOLE AND HANDHOLE CONSTRUCTION AND INSTALLATION

A. General Requirements:

- 1. Construct manholes of reinforced concrete.
- 2. Locate manholes and handholes at the approximate locations shown on the drawings with due consideration given to the location of other utilities, grades, and paving.
- 3. Steel reinforcing concrete cover, not less than 50 mm (2 inches) thick for exterior surfaces, 38 mm (1 1/2 inches) thick for interior surfaces, and 25 mm (1 inch) thick for the bottom surfaces of the top slabs.
- 4. Walls, floors, and top:
 - a. Construct monolithic walls and floors with window openings in walls for ducts.
 - b. Provide sump pits in the floor of manholes for drainage.
 - c. Provide manhole with a circular opening suitable for the installation of the frame and cover. Provide water stops at framed cold joints.

5. Duct terminations: Provide windows at duct bank terminations and fill with concrete after duct placement. Terminations shall be sealed watertight.

6. Pulling irons:

- a. Provide pulling irons opposite each duct entrance.
- b. Cast pulling irons in the walls opposite duct windows approximately 152mm (6 inches) above the top of the window.

B. Manhole Access:

1. Manhole chimney shall consist of a sufficient number of brick and mortar courses between top of manhole and manhole frame to reach the required level. Grout the manhole frame to the chimney.
2. The top of frames and covers shall be flush type, with the finish flush with finished grade in paved and unpaved areas.
3. Frames and covers in roadways and paved areas shall be traffic type. In unpaved areas frames and covers may be non-traffic type.

C. Access for Handholes: Make the top of frames and covers flush with finished grade.

D. Manhole Cable Racks:

1. Provide cable racks with porcelain insulator supports in each manhole.
2. Cable support intervals shall not exceed 900mm (36 inches).
3. Install racks at the above spacing on all walls for not less than one cable, whether or not the racks will be used for cables. Install additional racks as required for the cables.
4. Each rack shall include cable support insulators.

E. Ground Rods and Grounding in Manholes:

1. Ground rods:

- a. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
- b. Poured-in-place manholes: Drive a ground rod into the earth, before the floor is placed, at a convenient point close to the manhole wall.
- c. Precast manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with a sealant to make a watertight seal.

2. Grounding Conductors:

- a. Install a 95 mm² (3/0 AWG) bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
 - b. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
 - c. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum 16 mm² (6 AWG) bare copper jumper.
- F. Precast Units:
1. Precast units shall have the same accessories and facilities as specified above.
 2. Assembly and installation of precast components shall follow the printed instructions and recommendations of the manufacturer of the units.
 3. Units shall be installed on a 300 mm (12 inch) level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inch) sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.
 4. Seal duct terminations watertight.
- G. Ladders: Provide securely mounted ladder for every manhole over 1200 mm (4 feet) deep.

3.2 TRENCHING

- A. Refer to Section 31 20 00, EARTH MOVING for trenching back-filling, and compaction.
- B. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.
- C. Cut the trenches neatly and uniformly.
- D. For Concrete Encased Ducts:
 1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1200 mm (4 foot) intervals to establish the grade and route of the duct bank.
 2. Pitch the trenches uniformly towards manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts towards buildings wherever possible.
 3. The walls of the trench may be used to form the side walls of the duct bank provided that the soil is self-supporting and that

concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.

4. After the concrete encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, with appropriate warning tape attached.

E. Conduits to be installed under existing paved areas, roads, and railroad tracks that are not to be disturbed shall be jacked into place. Conduits shall be PVC-coated rigid metal.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC and IEEE C2, as shown on the drawings, and as specified.
2. Slope ducts to drain towards manholes and handholes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inches) in 30 M (100 feet).
3. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be PVC-coated galvanized rigid steel, and shall extend a minimum of 1500 mm (5 feet) outside of building foundation.
4. Stub-ups, sweeps, and risers to equipment mounted on outdoor concrete slabs shall be PVC-coated galvanized rigid steel, and shall extend a minimum of 1500 mm (5 feet) away from edge of slab.
5. Install insulated grounding bushings on the terminations.
6. PVC-coated rigid steel conduits shall be coupled to the ducts with suitable adapters, and the whole encased with 75 mm (3 inches) of concrete.
7. PVC coated rigid steel conduit turns of direction for all duct lines shall have minimum 1200 mm (4 feet) radius in the horizontal and vertical directions. PVC conduit sweeps for all duct lines shall have a minimum 12000 mm (40 feet) radius in the horizontal and 1200 mm (4 feet) in the vertical directions. Where a 12000 mm (40 feet) radius is not possible, horizontal turns of direction shall be rigid steel.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above bottom of trench during the concrete pour. Spacer spacing shall not exceed 1500 mm (5 feet).
9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, and chilled water.

10. Clearances between individual ducts:
 - a. For like services, not less than 75 mm (3 inches).
 - b. For power and signal services, not less than 150 mm (6 inches).
 - c. Provide plastic spacers to maintain clearances.
 - d. Provide nonferrous tie wires to prevent displacement of the ducts during pouring of concrete. Tie wires shall not act as substitute for spacers.
 11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
 12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to insure maximum strength and rigidity of the duct bank.
 13. Keep ducts clean of earth, sand, or gravel during construction, and seal with tapered plugs upon completion of each portion of the work.
- B. Concrete Encased Ducts and Conduits:
1. Install concrete encased ducts for medium and high voltage systems, low voltage systems, and signal systems unless otherwise shown on the drawings.
 2. Duct lines shall consist of single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
 3. Tops of concrete-encased ducts shall be:
 - a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
 - b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Conduits crossing under grade slab construction joints shall be installed a minimum of 1200 mm (4 feet) below slab.
 4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts and conduits.
 5. Within 3000 mm (10 feet) of building, manhole and handhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
 6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
 7. Where new ducts, conduits, and concrete envelopes are to be joined to existing manholes, handholes, ducts, conduits, and concrete

- envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to insure smooth durable transitions.
8. Conduit joints in concrete may be placed side by side horizontally but shall be staggered at least 150 mm (6 inches) vertically.
 9. For medium voltage duct bank installations, a grounding conductor shall be extend along all electrical duct banks including stubs through each electrical distribution system manhole and to each transformer and switching-station installation.
 10. Duct Bank Markers:
 - a. Duct bank markers, where required, shall be located at the ends of duct banks except at manholes or handholes at approximately every 60 meter (200 feet) along the duct run and at each change in direction of the duct run. Markers shall be placed 600 mm (2 feet) to the right of the duct bank, facing the longitudinal axis of the run in the direction of the electrical load.
 - b. The letter "D" with two arrows shall be impressed or cast on top of the marker. One arrow shall be located below the letter and shall point toward the ducts. Second arrow shall be located adjacent to the letter and shall point in a direction parallel to the ducts. The letter and arrow adjacent to it shall each be approximately 75 mm (2-inches) long. The letter and arrows shall be V-shaped, and shall have a width of stroke at least 6 mm ($\frac{1}{4}$ inch) at the top and a depth of 6 mm ($\frac{1}{4}$ inch).
 - c. In paved areas, the top of the duct markers shall be flush with the finished surface of the paving.
 - d. Where the duct bank changes direction, the arrow located adjacent to the letter shall be cast or impressed with an angle in the arrow the same as the angular change of the duct bank.
 - C. Concrete-Encased and Direct Burial Duct and Conduit Identification:

Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts or conduits before backfilling trenches. Warning tape shall be preprinted with proper identification.
 - D. Spare Ducts and Conduits: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
 - E. Duct and Conduit Cleaning:
 1. Upon completion of the duct bank installation or installation of direct buried ducts, a standard flexible mandrel shall be pulled

through each duct to loosen particles of earth, sand, or foreign material left in the line. The mandrel shall be not less than 3600 mm (12 inches) long, and shall have a diameter not less than 13 mm (1/2 inch) less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than the diameter of the duct.

2. Mandrel pulls shall be witnessed by the COTR.

- F. Duct and Conduit Sealing: Seal the ducts and conduits at building entrances, and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.
- G. Connections to Manholes: Duct bank envelopes connecting to underground structures shall be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm (12 inches) in each direction. Perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.
- H. Connections to Existing Manholes: For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.
- I. Connections to Existing Ducts: Where connections to existing duct banks are indicated, excavate around the duct banks as necessary. Cut off the duct banks and remove loose concrete from the conduits before installing new concrete-encased ducts. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks.
- J. Partially Completed Duct Banks: During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 600 mm (2 feet) back into the

envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (1 foot) apart. Restrain reinforcing assembly from moving during pouring of concrete.

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SECTION 26 05 71**ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. This section specifies the requirements of the Electrical System Protective Device Study.
- B. A short circuit and coordination study shall be prepared for the electrical over current devices to be installed under this project to assure proper equipment and personnel protection.
- C. The study shall present an organized time-current analysis of each protective device in series from the individual device back to the utility and the on-site generator sources. The study shall reflect the operation of each device during normal and abnormal current conditions.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 24 16, PANELBOARDS: Low voltage panelboards.
- C. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Primary distribution switchgear.
- D. Section 26 18 41, MEDIUM-VOLTAGE SWITCHES: Primary switches.
- E. Section 26 24 11, DISTRIBUTION SWITCHBOARDS: Low voltage distribution switchboards.
- F. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: Low voltage switchgear.

1.3 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS , submit the following:
- B. Complete short circuit and coordination study as described herein.
- C. Protective equipment shop drawings shall be submitted simultaneously with or after the protective device study. Protective equipment shop drawings will not be accepted prior to protective device study.
- D. Certification: Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - 1. Certification by the Contractor that the protective devices have been adjusted and set in accordance with the approved protective device study.

1.4 QUALIFICATIONS

The protective device study shall be prepared by qualified engineers of the high voltage switchgear manufacturer or an approved consultant. The

Contractor is responsible for providing all pertinent information required by the preparers to complete the study.

1.5 REQUIREMENTS

- A. The complete study shall include a system one line diagram, short circuit and ground fault analysis, arc flash analysis per NFPA 70E and protective coordination plots.
- B. One Line Diagram:
 - 1. Show, on the one line diagram, all electrical equipment and wiring to be protected by the overcurrent devices installed under this project. Clearly show, on the one line, the schematic wiring of the electrical distribution system.
 - 2. Also show on the one line diagram the following specific information:
 - a. Calculated fault impedance, X/R ratios, and short circuit values at each bus.
 - b. Breaker and fuse ratings.
 - c. Generator kW and Transformer kVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.
 - d. Voltage at each bus.
 - e. Identification of each bus.
 - f. Conduit material, feeder sizes, length, and X/R ratios.
- C. Short Circuit Study:
 - 1. Systematically calculate the fault impedance to determine the available short circuit and ground fault currents at each bus. Incorporate the motor contribution in determining the momentary and interrupting ratings of the protective devices.
 - 2. The study shall be calculated by means of a computer program. Pertinent data and the rationale employed in developing the calculations shall be incorporated in the introductory remarks of the study.
 - 3. Present the data determined by the short circuit study in a table format. Include the following:
 - a. Device identification.
 - b. Operating voltage.
 - c. Protective device.
 - d. Device rating.
 - e. Calculated short circuit current.
- D. Coordination Curves:
 - 1. Prepare the coordination curves to determine the required settings of protective devices to assure selective coordination to the largest branch circuit overcurrent protection device at panelboard.

- Graphically illustrate on log-log paper that adequate time separation exists between series devices, including the utility company upstream device. Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices will be clearly depicted on one sheet.
2. The following specific information shall also be shown on the coordination curves:
 - a. Device identification.
 - b. Voltage and current ratio for curves.
 - c. 3-phase and 1-phase ANSI damage points for each transformer.
 - d. No-damage, melting, and clearing curves for fuses.
 - e. Cable damage curves.
 - f. Transformer inrush points.
 - g. Maximum short circuit cutoff point.
 3. Develop a table to summarize the settings selected for the protective devices. Include the following in the table:
 - a. Device identification.
 - b. Relay CT ratios, tap, time dial, and instantaneous pickup.
 - c. Circuit breaker sensor rating, long-time, short-time, and instantaneous settings, and time bands.
 - d. Fuse rating and type.
 - e. Ground fault pickup and time delay.
- E. Arc Flash Analysis
1. Provide arc flash labels for all electrical equipment indicate on single line diagram.
 2. Study shall indicate energy levels at each electrical component.
 3. Provide schedule of garment protection for each energy level.

1.6 ANALYSIS

- A. Analyze the short circuit calculations, and highlight any equipment that is determined to be underrated as specified. Propose approaches to effectively protect the underrated equipment. Provide minor modifications to conform with the study (Examples of minor modifications are trip sizes within the same frame, the time curve characteristics of induction relays, C.T. ranges, etc.).
- B. After developing the coordination curves, highlight areas lacking coordination. Present a technical evaluation with a discussion of the logical compromises for best coordination.

1.7 ADJUSTMENTS, SETTINGS AND MODIFICATIONS

- A. Necessary final field adjustments, settings and minor modifications shall be made to conform with the protective device study without additional cost to the Government.
- B. All final circuit breaker and relay settings and fuse sizes shall be made in accordance with the recommendations of the protective device study by a NETA Certified Third Party Testing Agency.
- C. Provide recommendations to reduce energy levels at electrical equipment.

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SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following lighting control devices:
1. Time switches.
 2. Outdoor photoelectric switches.
 3. Indoor occupancy sensors.
 4. Outdoor motion sensors.
 5. Lighting contactors.
 6. Emergency shunt relays.
- B. Related Sections include the following:
1. Division 26 Section "Central Dimming Controls and Modular Dimming Controls" for architectural dimming system equipment
 2. Division 26 Section "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.
 3. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.
 4. Division 26 Section "Theatrical Lighting" for theatrical lighting controls.

1.3 DEFINITIONS

- A. LED: Light emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

- A. Coordinate layout and installation of ceiling mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire suppression system and partition assemblies.

PART 2 - PRODUCTS**2.1 TIME SWITCHES**

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Sensor Switch, Inc. or a comparable product by one of the following:
1. Intermatic, Inc.
 2. Leviton Mfg. Company Inc.
 3. TORK
 4. Watt Stopper (The)
- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
1. Contact Configuration: SPST.
 2. Contact Rating: 20-A ballast load, 120-/240-V ac.
- C. Electromechanical-Dial Time Switches: Comply with UL 917.
1. Contact Configuration: SPST.
 2. Contact Rating: 20-A ballast load, 120-/240-V ac.
 3. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
 4. Astronomic time dial.
 5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
 6. Skip-a-day mode.
 7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Sensor Switch, Inc. or a comparable product by one of the following:
1. Cooper Industries, Inc.

2. Intermatic, Inc.
 3. NSi Industries LLC; TORK Products.
 4. Tyco Electronics; ALR Brand.
- B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
 2. Time Delay: Fifteen second minimum, to prevent false operation.
 3. Surge Protection: Metal-oxide varistor.
 4. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
- C. Description: Solid state, with SPST dry contacts rated for 1800 VA, to operate connected load, complying with UL 773.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
 2. Time Delay: Thirty-second minimum, to prevent false operation.
 3. Lightning Arrester: Air-gap type.
 4. Mounting: Twist lock complying with NEMA C136.10, with base.

2.3 INDOOR OCCUPANCY SENSORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Sensor Switch, Inc. or comparable product by one of the following:
1. Hubbell Building Automation, Inc.
 2. Leviton Mfg. Company Inc.
 3. Watt Stopper.
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
5. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
7. Bypass Switch: Override the "on" function in case of sensor failure.
8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- C. PIR Type: Ceiling mounted; detect occupants in coverage area by their heat and movement.
 1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.
- D. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy .
 1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.
- E. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR/Micro-Phone ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.

2.4 LIGHTING CONTACTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide ASCO Power Technologies or comparable product by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. Eaton Corporation.
 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution; Total Lighting Control.
 4. Grasslin Controls Corporation; a GE Industrial Systems Company
 5. Square D; a brand of Schneider Electric.
 6. Touch Plate, Inc.
- B. Description: Electrically operated and electrically held, combination-type lighting contactors with fusible switch, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and

- high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 3. Enclosure: Comply with NEMA 250.

2.5 EMERGENCY SHUNT RELAY

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Bodine or comparable product by one of the following:
 1. Dual Lite
- B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
 1. Coil Rating: 120 and 277 V.

2.6 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Division 26 Section "Network Lighting Controls."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

Solicitation No. VA-101-10-RP-0130

VAPHS - University Drive Division
Research Office Building - Building 30

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SECTION 26 09 36
MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
1. Manual modular dimming controls.
 2. Integrated, multipreset modular dimming controls.

1.3 DEFINITIONS

- A. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
- C. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
- D. SCR: Silicon-controlled rectifier.
- E. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
1. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
 2. Device plates and plate color and material.
 3. Ballasts and lamp combinations compatible with dimmers.
 4. Wiring Diagrams: Power, signal, and control wiring.
- B. Samples for Initial Selection: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.
- C. Samples for Verification: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:
 - 1. Division 26 Section "Lighting Control Devices."

PART 2 - PRODUCTS**2.1 GENERAL DIMMING DEVICE REQUIREMENTS**

- A. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
- B. Dimmers and Dimmer Modules: Comply with UL 508.
 - 1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
 - 2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

2.2 MANUAL MODULAR MULTISCENE DIMMING CONTROLS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products by one of the following:
 - 1. Leviton Mfg. Company Inc.
 - 2. Lightolier Controls; a division of Lightolier; a Genlyte Group.
 - 3. Lutron Electronics, Inc.
- B. Description: Factory-fabricated equipment providing manual modular dimming control consisting of a wall-box-mounted, master-scene controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in one-, two-, or three-gang wall box under a single wall plate. Each zone station shall be adjustable to indicated number of scenes, which shall be recorded on the zone controller.

- C. Operation: Automatically change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
- D. Each manual modular multiscene dimming controller shall include a master control and remote controls.
- E. Each zone shall be configurable to control the following:
1. Fluorescent lamps with electronic ballasts.
 2. Incandescent lamps.
 3. Low-voltage incandescent lamps.
- F. Memory: Retain preset scenes through power failures for at least seven days.
- G. Device Plates: Style, material, and color shall comply with Division 26 Section "Wiring Devices."
- H. Master-Scene Controller: Suitable for mounting in a single flush wall box.
1. Switches: Master off, group dim, group bright, and selectors for each scene.
 2. LED indicator lights, one associated with each scene switch, and one for the master off switch.
- I. Fluorescent Zone Dimmer: Suitable for operating lighting fixtures and ballasts specified in Division 26 Section "Interior Lighting," and arranged to dim number of scenes indicated for the master-scene controller. Scene selection is at the master-scene controller for setting light levels of each zone associated with scene.
1. Switch: Slider style for setting the light level for each scene.
 2. LED indicator lights, one associated with each scene.
 3. Electrical Rating: 2000 VA, 120 V.
- J. Incandescent Zone Dimmer: Suitable for operating incandescent lamps at line-voltage or low-voltage lamps connected to a transformer and arranged to dim number of scenes indicated for the master-scene controller. Scene selection shall be at the master-scene controller for setting light levels of each zone associated with scene.
1. Switch: Slider style for setting the light level for each scene.
 2. LED indicator lights, one associated with each scene.
 3. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.

2.3 INTEGRATED, MULTIPRESET MODULAR DIMMING CONTROLS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide Lutron Grafik Eye, QS or a comparable product by one of the following:
 - 1. Leviton Mfg. Company Inc.
 - 2. Lightolier Controls; a division of Lightolier; a Genlyte Group.
- D. Indicate number of wall-box, remote-control stations.
- E. Description: Factory-fabricated, microprocessor-based, solid-state controls providing manual dimming control consisting of a master station and multiple wall-box, remote-control stations.
- F. Operation: Automatically changes variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
- G. Each zone shall be configurable to control the following:
 - 1. Fluorescent lamps with electronic ballasts.
 - 2. Incandescent lamps.
 - 3. Low-voltage incandescent lamps.
- H. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.
- I. Master Station:
 - 1. Contains control panel and multiple control and dimmer modules.
 - 2. Controls and commands adjustment of each dimmer-zone setting for each scene change from one preset scene to another.
 - a. Master zone raises and lowers lighting level.
 - b. Adjustable fade rate for each scene from 1 to 60 seconds.
 - 3. Rear-illuminated, scene-select buttons.
 - 4. Lighting-level setting and fade-rate setting shall be graphically shown using LEDs or backlighted bar-graph indicator.
 - 5. Mounting: Flush wall box with manufacturer's standard faceplate.
- J. Remote-Control Stations:
 - 1. Engraved push buttons to select scenes.
 - 2. Off switch to turn master station off.
 - 3. On switch turns all scenes of master station to full bright.

4. Control Wiring: NFPA 70, Class 2.

5. Mounting: Single flush wall box with manufacturer's standard faceplate.

K. Infrared Remote-Control Station: Same functions as for standard remote-control station, except that functions are input by a hand-held infrared transmitter.

L. Dimmers: Modular, plug-in type, with circuit breaker to protect the dimmer and branch circuit.

1. Dimming Circuit: Triac dimmers.

2. Dimming Curve: Modified "square law" as specified in IESNA's "IESNA Lighting Handbook".

3. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.

4. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.

5. Short-Circuit Rating: 14 kA for 277 V.

2.4 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" for identifying components and power and control wiring.
- B. Label each dimmer module with a unique designation.
- C. Label each scene control button with approved scene description.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
- a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
- D. Remove and replace malfunctioning modular dimming control components and retest as specified above.
- E. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- F. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls.

- B. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."

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SECTION 26 09 43
NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes manually operated lighting controls with relays and control module.
- B. Section includes manually operated, PC-based, digital lighting controls with external signal source, relays and control module.
- C. Section includes individually addressable lighting control devices communicating with data-entry and -retrieval devices using DALI protocol.
- D. Related Sections:
 - 1. Division 26 Section "Lighting Control Devices" for time clocks, photoelectric sensors, occupancy sensors, and multipole contactors.
 - 2. Division 26 Section "Central Dimming Controls" or "Modular Dimming Controls" for dimming control components.

1.3 DEFINITIONS

- A. BACnet: A networking communication protocol that complies with ASHRAE 135.
- B. BAS: Building automation system.
- C. DALI: Digital addressable lighting interface.
- D. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
- F. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- G. PC: Personal computer; sometimes plural as "PCs."

H. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.

I. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, DALI network materials, manual switches and plates, and conductors and cables.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

C. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.

1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.

2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

D. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

- 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
- 3. Device address list.
- 4. Printout of software application and graphic screens.
- E. Field quality-control reports.
- F. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- G. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- H. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
- E. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of lighting control functions.
- B. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards."

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of software input/output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.

2. Warranty Period: Two years from date of Substantial Completion.

1.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of the software.
 - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
 - 1. Leviton Mfg. Company Inc.
 - 2. Lutron Electronics Co., Inc.
 - 3. Watt Stopper (The)

2.2 SYSTEM REQUIREMENTS

- A. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.
- B. Performance Requirements: Manual switch operation sends a signal to network-system control module that processes the signal according to its programming and routes an open or close command to one or more relays in the power-supply circuits to groups of lighting fixtures or other loads.
- C. Performance Requirements: Manual switches, an internal timing and control unit, and external sensors or other control signal sources send a signal to a PC-based network-system control module that processes the signal according to its programming and routes an open or close command to one or more relays in the power-supply circuits, or routes variable commands to one or more dimmers, for groups of lighting fixtures or other loads.

- D. Performance Requirements: Individually addressable devices (such as electronic ballasts, dimmers, and manual switches) are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs). Devices also report status to data-entry and -retrieval devices through the bus.

2.3 CONTROL MODULE

- A. Control Module Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Control units shall be networked and capable of receiving inputs from indicated sensors. Output circuits shall be pilot-duty relays compatible with power switching devices. Output circuits shall include digital circuits arranged to transmit control commands to remote preset dimmers.
- B. Control Module Description (**Base Bid**): Comply with UL 508 (CAN/CSA C22.2, No. 14); microprocessor-based, networked, control unit; mounted in preassembled, modular relay panel. Low-voltage-controlled, latching-type, single-pole lighting circuit relays shall be prime output circuit devices. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays. Control units shall be capable of receiving inputs from sensors and other sources. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable.
- C. Control Module Description (**Alternate #3**): Programmable, PC-based unit with 17-inch color video monitor and keyboard for graphic display and programming of system status and to override relay status; and to display status of local override controls and diagnostic information. If the control module is applied to emergency lighting units, control unit shall indicate failure of normal power and that the lighting units are, or are not, powered by the alternate power source.
1. Display: Single graphic display for programming lighting control relay panels.

2. Interoperability: Control module shall be configured to connect with other control systems using RS-485 network to enable remote workstations to use control module functions.
3. Software: Lighting control software shall be capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses, and assigning switch input and relay output modes.
4. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight saving time and shall provide weekly routine and annual holiday scheduling.
5. Astronomic Control: Automatic adjustment of dawn and dusk switching.
6. Confirmation: Each relay or contactor device operated by system shall have auxiliary contacts that provide a confirmation signal to the system of on or off status of device. On or off status confirmation for each electrically operated circuit breaker shall be provided by an auxiliary contact or by a sensing device at load terminal.
 - a. Software shall interpret status signals, provide for their display, and initiate failure signals.
 - b. Lamp or LED at control module or display panel shall identify status of each controlled circuit.
7. Remote Communication Capability: Allow programming, data-gathering interrogation, status display, and controlled command override from a PC at a remote location over telephone lines. System shall include modem, communications and control software, and remote computer compatibility verification for this purpose.
8. Local Override Capability: Manual, low-voltage control devices shall override programmed shutdown of lighting and shall override other programmed control for intervals that may be duration programmed.
9. Automatic Control of Local Override: Automatic control shall switch lighting off if lighting has been switched on by local override.
10. Automatic battery backup shall provide power to maintain program and system clock operation for 90 days' minimum duration when power is off.

11. Programmed time signals shall change preset scenes and dimmer settings.
12. Daylight Balancing Dimming Control: Control module shall interpret variable analog signal from photoelectric sensor and shall route dimming signals to dimming fluorescent ballast control circuits. Signal shall control dimming of fixture so illumination level remains constant as daylight contribution varies.
13. Energy Conservation: Bilevel control of special ballasts or dimming circuits to comply with local energy codes.
14. Flick Warning: Programmable momentary turnoff of lights shall warn that programmed shutoff will occur after a preset interval. Warning shall be repeated after a second preset interval before end of programmed override period.
15. Diagnostics: When system operates improperly, software shall initiate factory-programmed diagnosis of failure and display messages identifying problem and possible causes.
16. Additional Programming: In addition to system programming by the PC, individual control modules shall be networked and programmable using data-entry and -retrieval (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs).

2.4 POWER DISTRIBUTION COMPONENTS

- A. Modular Relay Panel: Comply with UL 508 (CAN/CSA C22.2, No. 14) and UL 916 (CSA C22.2, No. 205); factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.
 1. Cabinet: Steel with hinged, locking door.
 - a. Barriers separate low-voltage and line-voltage components.
 - b. Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.
 - c. Control Power Supply: Transformer and full-wave rectifier with filtered dc output.
 2. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.
 - a. Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.

- b. Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.
- c. Endurance: 100,000 cycles at rated capacity.
- d. Mounting: Provision for easy removal and installation in relay cabinet.

2.5 DALI NETWORK MATERIALS

- A. Network Power Supply and Router: Interface device connecting TCP/IP control networks to DALI-compliant network.
 - 1. DALI-Compliant Network Power Rating: One full-rated network for powering up to 64 addressable devices for each network; suitable for use with NFPA 70, Class 1 and Class 2 control circuits; and 16 V dc, 250 mA.
 - 2. Primary Power: 120 or 277 V, field selectable; 12 VA.
 - 3. 10baseT Ethernet port.
 - 4. LED indicator lights for Ethernet status (link, send, and receive), power-on, and DALI network failure.
- B. Lighting Control Software:
 - 1. Five-tier hierarchical architecture; high-speed, parallel query; and distributed-logic processing scalable from single rooms to full campuses.
 - 2. Automatic backup for all settings and parameters.
 - 3. TCP/IP network protocol.
 - 4. Interactive with other building management systems at TCP/IP level.
 - 5. At least three security levels.
 - 6. Support the full suite of DALI commands and device parameter settings.
 - 7. Scheduling modules to provide building-wide scene scheduling.
 - 8. Billing modules to track energy use for multiple tenants and able to produce monthly billing statements.
 - 9. Support load shedding, peak shaving, sweeps with local override, and other energy-conservation measures.
 - 10. Able to report individual device status, including inoperative lamps, ballast failure detection, and dimmer position.

2.6 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Modular, momentary-contact, low-voltage type.
 - 1. Match color specified in Division 26 Section "Wiring Devices."
 - 2. Integral green LED pilot light to indicate when circuit is on.

- B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Division 26 Section "Wiring Devices."
- C. Wall-Box Dimmers: Comply with Division 26 Section "Wiring Devices."
- D. Wall Plates: Single and multigang plates as specified in Division 26 Section "Wiring Devices."
- E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.7 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- D. Structured Network Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e for horizontal copper cable and with Division 27 Section "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install wiring in raceways. Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables" Minimum conduit size shall be 1/2 inch.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
- D. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- E. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.

G. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Test for circuit continuity.
2. Verify that the control module features are operational.
3. Check operation of local override controls.
4. Test system diagnostics by simulating improper operation of several components selected by Architect.

3.3 SOFTWARE INSTALLATION

A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

3.4 ADJUSTING

A. Occupancy Adjustments: To adjust, program or modify the system to suite actual occupied condition and operations. Provide multipole visits to Project during other-than-normal occupancy hours for adjustment of the System.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls. Provide a complete commissioning test plan indicating the personnel required to fully commission the installed system.

- - - END - - -

SECTION 26 11 16
SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL**1.1 DESCRIPTION**

This section specifies the furnishing, installation, and connection of the secondary unit substation, complete and ready for operation.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Electrical coordination study of overcurrent protection devices.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.
- D. Section 26 25 11, BUSWAYS: Feeder busways and fittings.
- E. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium voltage cables.
- F. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage cable and wiring.
- G. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- H. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL: For metering devices integral to the secondary unit substation.
- I. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Medium-voltage circuit breakers for use in secondary unit substations.
- J. Section 26 18 41, MEDIUM-VOLTAGE SWITCHES: Medium-voltage switches for use in secondary unit substations.
- K. Section 26 24 11, DISTRIBUTION SWITCHBOARDS: Secondary distribution switchboards.
- L. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: Secondary distribution switchgear.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Substations shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Tests shall be conducted as per UL and ANSI Standards. Factory tests shall be certified. The following tests shall be performed:

1. Medium Voltage Section: Refer to Section 26 18 41, MEDIUM-VOLTAGE SWITCHES, and Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR.
2. Transformer Section:
 - a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground.
 - b. Perform turns-ratio tests at all tap positions.
3. Low Voltage Section: Refer to Section 26 23 00, LOW VOLTAGE SWITCHGEAR, and Section 26 24 11, DISTRIBUTION SWITCHBOARDS.

1.5 SUBMITTALS

Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:

A. Shop Drawings:

1. Include sufficient information, clearly presented, to determine compliance with drawings and specifications.
2. Include electrical ratings, dimensions, mounting details, winding materials, required clearances, terminations, fuses (if required), safety features, weight, decibel rating, temperature rise, nominal impedance, regulation, no load and full load losses, wiring and connection diagrams, front, side and rear elevations, sectional views, coordination curves, transformer no-load and full-load losses, accessories and nameplate data.

B. Manuals:

1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts. It shall also include installation, operating instructions, maintenance, trouble shooting and repair procedures and technical literature pertaining to all components or instruments provided.
2. Two weeks prior to final inspection, submit four copies of the final up-dated maintenance and operating manuals to the COTR.

C. Tests:

1. Submit, simultaneously with the shop drawings, certification that the following tests were performed at the factory: insulation-resistance tests, high-potential tests,

D. Certificates:

1. Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - a. Certification by the Contractor that the substations have been properly installed, adjusted, and tested, including final circuit breaker settings.

- b. Certified copies of all of the factory design and production tests, field test data sheets and reports for the substations.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. American Concrete Institute (ACI):
ACI 318.....Building Code Requirements for Structural Concrete.
- C. American Society for Testing and Materials (ASTM):
D3487.....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.
- D. Institute of Electrical and Electronic Engineers (IEEE):
C37.121American National Standard for Switchgear- Unit Substations- Requirements
C62.11.....Metal Oxide Surge Arresters for AC Power Circuits
C62.41.....Surge Voltage in Low Voltage AC Power circuits
C57.12.00.....Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
C57.12.01.....Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings
- E. National Fire Protection Association (NFPA):
70.....National Electrical Code (NEC):

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Secondary unit substation shall be in accordance with ASTM, ANSI, IEEE, NEC, and as shown on the drawings.
- B. The secondary unit substation shall be a complete, grounded, continuous-duty, unitized integral assembly; metal clad, dead-front, dead-rear type; with liquid-immersed transformer. Substation shall be designed for indoor service with ventilation openings.
- C. Ratings shall be not less than required by the NEC and not less than shown on the drawings. Short circuit current ratings shall be not less than the maximum short circuit currents available, where the substation is being installed, as shown on the drawings.

- D. Provide substations that conform to the arrangements and details shown on the drawings and to the space designated for installation.
- E. Coordinate the components of the substations and their arrangements electrically and mechanically. Coordinate all circuit entrances into the substations, including methods of entrance and connections.
- F. Incorporate interlocking as shown on the drawings and as required for the safe operation of the substations.
- G. The substation shall be assembled and prewired by the manufacturer at the factory. Substation shall be subassembled and shipped in complete sections ready for connection at the site. Where practicable, substation shall be shipped as one unit.
- H. Substation shall be thoroughly cleaned, phosphate treated and painted at the factory with rust-inhibiting paint and baked enamel or lacquer light gray finish.
- I. Provide unit strip heaters inside enclosure and controlled utilizing a thermostat/humidistat device.

2.2 MEDIUM VOLTAGE SECTION

- A. Housing shall be of indoor type.
- B. Preformed Terminations:
 - 1. May be used for cables.
 - 2. Shall conform to the requirements in Section 26 05 13, MEDIUM-VOLTAGE CABLES.
 - 3. Medium voltage section shall be close coupled to transformer.
 - 4. Independently support each cable by a clamp to a structural support within 6 inches (152.4mm) of the termination to relieve any strain imposed by cable weight or movement.
- C. Medium Voltage Surge Arresters:
 - 1. Distribution class, metal-oxide-varistor type. Comply with NEMA LA 1.
 - 2. Provide each ungrounded conductor of each incoming circuit with an arrester.
- D. Medium Voltage Fused Switch:
 - 1. Refer to Section 26 18 41, MEDIUM VOLTAGE SWITCHES.
- E. Interrupting ratings shall be not less than the maximum short circuit current available where the substation is being installed, as shown on the drawings.

2.3 SILICON TRANSFORMERS

- A. Shall have the following features:
 - 1. Self-cooled by natural convection, isolating windings, indoor type.
 - 2. Auto-transformers will not be accepted.

3. Ratings indicated are for continuous-duty without the use of cooling fans.
4. Temperature rises shall not exceed the following NEMA Standard test values for the respective insulation systems: 65 degrees C (149 degrees F) by resistance and 80 degrees C (176 degrees F) hottest spot.
5. Transformer insulating silicone shall be in accordance with ASTM.
6. Nominal impedance shall be 5.75 percent.
7. Sound levels shall conform to 3dB below the NEMA Standards.
8. Primary and secondary windings:
 - a. Primary windings shall be delta-connected.
 - b. Secondary windings shall be wye-connected except where otherwise shown on the drawings.
 - c. Leads shall be brought out through wet process, porcelain busings, pressure-tight.
 - d. Shall have secondary neutral bushings for transformers with wye connected secondary windings.
 - e. Terminals shall be the most suitable clamp or blade type as required for the circuit connections.
9. Four, 2-1/2 percent full capacity taps in the primary windings, with two taps above rated voltage and two taps below rated voltage.
10. Core and Coil Assemblies:
 - a. Assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment and the stresses caused by short circuit currents.
 - b. Cores shall be grain-oriented, non-aging, silicon steel.
 - c. Core and coil assembly shall be immersed in silicone or R-Temp fluid.
 - d. Coils shall be continuous windings without splices except for taps.
 - e. Coil loss and core loss shall be optimum for efficient operation.
 - f. Primary, secondary and tap connections shall be brazed or pressure type.
 - g. Coil windings shall have end fillers or tie downs.
11. Tanks, covers and radiators shall be not less than code gage steel. Outdoor units shall have an additional coat of paint baked-on, and the underside shall be coated with asphalt.
12. Standard NEMA features and accessories including the following:
 - a. A suitable tap changer for de-energized operation.
 - b. Lifting, pulling and jacking facilities.

- c. Globe type valves for filtering and draining.
 - d. A grounding pad.
 - e. A dial type liquid thermometer with a maximum reading pointer and an external reset.
 - f. A liquid level gage.
 - g. A pressure relief device.
 - h. A diagrammatic nameplate, including date of manufacture.
13. All winding materials shall be copper.
14. The energy efficiency requirement values per NEMA TP-1 for Silicon filled transformers are listed below:

<u>kVA</u>	<u>(%)</u>
500	98.7
750	98.8
1000	98.9
1500	99.0
2000	99.0
2500	99.1

2.4 LOW VOLTAGE SECTION

- A. Refer to Section 26 23 00, LOW-VOLTAGE SWITCHGEAR.

2.5 AUXILIARIES

- A. Install additional components as shown on the drawings or otherwise required for the substations.
- B. Provide warning signs for the enclosures of secondary unit substations having a nominal rating exceeding 600 volts.
1. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.29, such as for secondary unit substations, provide self-adhesive warning signs on the outside of the medium voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 inches by 10 inches (178mm by 255mm) with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch (50mm) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the secondary unit substation in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor secondary unit substation to the slab with plated 1/2 inch [12.5mm] minimum anchor bolts, or as recommended by the manufacturer.

- C. Interior Location. Mount secondary unit substation on concrete slab. Unless otherwise indicated, the slab shall be at least 4 inches [100mm] thick. The top of the concrete slab shall be approximately 4 inches [100mm] above finished floor. Edges above floor shall have 1/2 inch [12.5mm] chamfer. The slab shall be of adequate size to project at least 8 inches [200mm] beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches [75mm] above slab surface. Concrete work shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.
- D. Substation Grounding: Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches (610mm) below grade interconnecting the indicated ground rods. Surge arrester and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends. Substation transformer neutral connections shall not be smaller than No. 1/0 AWG.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform tests in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections.
- B. Medium Voltage Section
1. Refer to Section 26 18 41, MEDIUM-VOLTAGE SWITCHES, and Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR.
- C. Transformers (Liquid-Filled)
1. Compare equipment nameplate data with specifications and approved shop drawings.
 2. Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.
 3. Verify that control and alarm settings on temperature indicators are as specified.
 4. Inspect all field-installed bolted electrical connections, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization under load.
 5. Verify correct liquid level in transformer tank.
 6. Perform specific inspections and mechanical tests as recommended by manufacturer.
 7. Verify correct equipment grounding.

8. Verify the presence of transformer surge arresters.
9. Verify that the tap-changer is set at specified ratio.
10. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

D. Low Voltage Section

1. Refer to Section 26 23 00, LOW VOLTAGE SWITCHGEAR, and Section 26 24 11, DISTRIBUTION SWITCHBOARDS.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the secondary unit substations are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device.

3.4 TEMPORARY HEATING

Apply temporary heat to secondary unit substations, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.5 INSTRUCTIONS AND FINAL INSPECTION

- A. A complete set of operating instructions for the secondary unit substations shall be laminated or mounted under plexiglass and installed in a frame on the wall of switchgear assembly.
- B. Conduct a final inspection, in the presence of the COTR, to assure that the switchgear operates properly in all respects.
- C. Furnish the services of a factory-trained engineer for two, 4-hour training periods for instructing personnel in the maintenance and operation of the equipment, on the dates requested by the COTR.

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SECTION 26 18 41
MEDIUM-VOLTAGE SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of medium voltage switches.

1.2 RELATED WORK

- A. Section 09 06 00, SCHEDULE FOR FINISHES: Switch finishes.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- C. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium voltage cables and splices.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- E. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Short circuit and coordination study.
- F. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL: For metering devices integral to the medium-voltage switches.
- G. Section 26 27 13, ELECTRIC METERING: For revenue metering devices integral to the medium-voltage switches.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Medium voltage switches shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Tests shall be conducted as per UL and ANSI Standards. Factory tests shall be certified. The following tests shall be performed:
 - 1. Verify that fuse sizes and types are in accordance with drawings and coordination study.
 - 2. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - 3. Verify operation and sequencing of interlocking systems.
 - 4. Verify correct phase barrier installation.
 - 5. Verify correct operation of all indicating and control devices.

6. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 7. Exercise all active components.
 8. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data.
 9. Perform a dielectric withstand voltage test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage shall be in accordance with manufacturer's published data.
- B. Furnish four (4) copies of certified manufacturer's factory test reports to the COTR prior to shipment of the switches to ensure that the switches have been successfully tested as specified.

1.5 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
1. Provide detailed drawings with sufficient information, clearly presented, to determine compliance with drawings and specifications.
 2. Provide information such as complete electrical ratings, dimensions and approximate design weights, mounting details, materials, required clearances, cable terminations, fuse sizes and class, interrupting ratings, wiring and connection diagrams, front, side and rear elevations, sectional views, safety features, accessories and nameplate data.
- C. Manuals:
1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams and information for ordering replacement parts.
 2. Two weeks prior to the project final inspection, submit four copies of the final updated maintenance and operating manuals to the COTR. (Update the manuals to include any revisions necessitated by shop drawing approval).
- D. Certifications:
1. Two weeks prior to the project final inspection, submit four copies of the following to the COTR.
 - a. Certification by the Contractor that the equipment has been properly installed, adjusted and tested.
 - b. Certified copies of all factory test reports and any field test data sheets and reports.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American National Standards Institute (ANSI):
- C37.47.....Medium voltage Current-Limiting Type
Distribution Class Fuses and Fuse Disconnect
Switches
 - C37.58.....Conformance Test Procedures for Indoor AC
Medium-Voltage Switches for Use in Metal-
Enclosed Switchgear
- C. Institute of Electrical and Electronics Engineers (IEEE):
- C37.20.3.....Metal-Enclosed Interrupter Switchgear
 - C37.48.....Guide for Application, Operation and Maintenance
of Medium voltage Fuses, Distribution Enclosed
Single Pole Air Switches, Fuse Disconnecting
Switches and Accessories
- D. National Electrical Manufacturers Association (NEMA):
- C37.22.....Preferred Ratings and Required Capabilities for
Indoor AC Medium-Voltage Switches Used in Metal-
Enclosed Switchgear
 - SG 6.....Power Switching Equipment
- E. National Fire Protection Association (NFPA):
- 70.....National Electrical Code (NEC)

PART 2 - PRODUCTS**2.1 MEDIUM VOLTAGE AIR BREAK SWITCHES**

- A. Shall be in accordance with ANSI, IEEE, NEMA, NFPA, as shown on the drawings and have the following features:
1. Deadfront air break, three-pole gang-operated, rated load interrupter type, with manual stored energy operator.
 2. Copper blades.
 3. A separate door for the fuse section. A mechanical interlock shall prevent opening the door unless the switch blades are open, and prevent closing the switch if the door is open.
 4. Phase barriers for the full length of the blades and fuses for each pole.
 5. Protective shield to cover the cable connections on the line terminals.
 6. Quick-make, quick-break, stored energy type operation mechanism. The mechanism shall enable the switch to close against a fault equal to

- the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability.
7. External manual operating handle with lock-open padlocking provisions.
 8. When the switches are open, the fuses shall be de-energized.
 9. Current limiting, power type fuses.
 10. Provision for remote electrical operation.
 11. Enclosures:
 - a. NEMA type shown on the drawings for the switches. Where the types of switch enclosures are not shown, they shall be the NEMA types which are most suitable for the environmental conditions where the switches are being installed.
 - b. Doors:
 - 1) Concealed or semi-concealed hinges shall be used to attach doors. Weld hinges to the enclosure and door.
 - 2) Mechanically interlocked to prevent opening unless the switch blades are open.
 - 3) Three point door locking mechanism, suitable handles and padlocking provisions.
 - 4) Safety-glass window for viewing the switch blades.
 - 5) Door stops for the open position.
 - c. Finish:
 - 1) All metal surfaces shall be thoroughly cleaned, phosphatized, primed and painted at the factory.
 - 2) Final finish shall be enamel, lacquer or powder coating. Enamel and powder coatings shall be oven baked. Color shall be light gray.
 - B. Minimum switch fault close and momentary current rating shall be 60 kA with a 2 second current rating of 38 kA.

2.2 NAMEPLATES AND MIMIC BUS

- A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 1/2 inch [12mm] engraved lettered nameplates next to each switch. For Essential Electrical System, provide laminated red phenolic resin with white core with 1/2 inch [12mm] engraved lettered nameplates next to each switch. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of switches. Mounting nameplates only with adhesive is not acceptable.

- B. Mimic Bus: Provide an approved mimic bus on front of each switch assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the switches in accordance with the NEC, manufacturer's instructions and recommendations and as shown on the drawings.
- B. Anchor the units with rustproof bolts, nuts and washers not less than 1/2-inch [13mm] diameter.
- C. Interior Location. Mount switches on concrete slab. Unless otherwise indicated, the slab shall be at least 4 inches [100mm] thick. The top of the concrete slab shall be approximately 4 inches [100mm] above finished floor. Edges above floor shall have 1/2 inch [15mm] chamfer. The slab shall be of adequate size to project at least 100 mm 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches [75mm] above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections:
1. Compare equipment nameplate data with specifications and approved shop drawings.
 2. Inspect physical and mechanical condition.
 3. Confirm correct application of manufacturer's recommended lubricants.
 4. Clean switches.
 5. Verify appropriate anchorage and required area clearances.
 6. Verify appropriate equipment grounding.
 7. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
 8. Verify that fuse sizes and types correspond to approved shop drawings.
 9. Inspect all field-installed bolted electrical connections, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization under load.

10. Exercise all active components.
11. Test interlocking systems for correct operation and sequencing.
12. Inspect all indicating devices for correct operation.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that switches are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS

Two weeks prior to the final inspection, provide one (1) set of spare fuses for each fused switch installed on this project.

3.5 INSTRUCTION

Furnish the services of a factory certified instructor for one 4 hour period for instructing personnel in the operation and maintenance of the switchgear and related equipment on the date requested by the COTR.

- - - E N D - - -

SECTION 26 22 00**LOW-VOLTAGE TRANSFORMERS****PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation and connection of the dry type general-purpose transformers.

1.2 RELATED WORK

- A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of nonstructural components.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.
- D. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, impedance, dimensions, weight, mounting details, decibel rating, terminations, temperature rise, no load and full load losses, and connection diagrams.
 - 3. Complete nameplate data including manufacturer's name and catalog number.
- C. Manuals:
 - 1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets and wiring diagrams.
 - 2. If changes have been made to the originally submitted maintenance and operating manuals, then two weeks prior to final inspection submit four copies of updated maintenance and operating manuals to the COTR.

- D. Certifications: Two weeks prior to the final inspection, submit four copies of the following to the COTR:
1. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
 2. Certification that the equipment has been properly installed and tested.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Fire Protection Association (NFPA):
70-05.....National Electrical Code (NEC)
- C. National Electrical Manufacturers Association (NEMA):
ST 20-97.....Dry-Type Transformers for General Applications

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE DRY TYPE TRANSFORMERS

- A. Unless otherwise specified, dry type transformers shall be in accordance with NEMA, NEC and as shown on the drawings. Transformers shall be UL listed or labeled.
- B. Dry type transformers shall have the following features:
1. Self-cooled by natural convection, isolating windings, indoor, dry type. Autotransformers will not be accepted.
 2. Rating and winding connections shall be as shown on the drawings.
 3. Transformers shall have copper windings.
 4. Ratings shown on the drawings are for continuous-duty without the use of cooling fans.
 5. Insulation systems:
 - a. Transformers 30 KVA and larger: UL rated 220 degrees C system having an average maximum rise by resistance of 150 degrees C in a maximum ambient of 40 degrees C.
 - b. Transformers below 30 KVA: Same as for 30 KVA and larger or UL rated 185 degrees C system having an average maximum rise by resistance of 115 degrees C in a maximum ambient of 40 degrees C.
 6. Core and coil assemblies:
 - a. Rigidly braced to withstand the stresses caused by short circuit currents and rough handling during shipment.
 - b. Cores shall be grain oriented, non-aging, and silicon steel.
 - c. Coils shall be continuous windings without splices except for taps.

- d. Coil loss and core loss shall be minimum for efficient operation.
 - e. Primary and secondary tap connections shall be brazed or pressure type.
 - f. Coil windings shall have end fillers or tie downs for maximum strength.
7. Certified sound levels determined in accordance with NEMA, shall not exceed the following:

Transformer Rating	Sound Level Rating
0 - 9 KVA	40 dB
10 - 50 KVA	45 dB
51 - 150 KVA	50 dB
151 - 300 KVA	55 dB
301 - 500 KVA	60 dB

8. Nominal impedance shall be as shown on the drawings. If not shown on drawings, nominal impedance shall be as permitted by NEMA.
9. Single phase transformers rated 15 KVA through 25 KVA shall have two, 5 percent full capacity taps below normal rated primary voltage. All transformers rated 30 KVA and larger shall have two, 2-1/2 percent full capacity taps above, and four, 2-1/2 percent full capacity taps below normal rated primary voltage.
10. Core assemblies shall be grounded to their enclosures by adequate flexible ground straps.
11. Enclosures:
- a. Not less than code gage steel.
 - b. Outdoor enclosures shall be NEMA 3R.
 - c. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
 - d. Ventilation openings shall prevent accidental access to live components.
 - e. Thoroughly clean and paint enclosure at the factory with manufacturer's prime coat and standard finish.
12. Standard NEMA features and accessories including ground pad, lifting provisions and nameplate with the wiring diagram and sound level indicated on it.
13. Dimensions and configurations shall conform to the spaces designated for their installations.

14. Transformers shall meet the minimum energy efficiency values per NEMA TP1 as listed below:

kVA Rating	Output efficiency (%)
15	97
30	97.5
45	97.7
75	98
112.5	98.2
150	98.3
225	98.5
300	98.6
500	98.7
750	98.8

2.2 NONLINEAR TRANSFORMERS

- A. Transformers shall be designed to withstand the overheating effects caused by harmonics resulting from non-linear (non-sinusoidal) loads such as office equipment using solid-state switching power supplies (i.e. computers, laser printers and copiers).
- B. Copper coils' neutrals shall carry at least 200% of normal phase current.
- C. Minimum efficiency designed to supply circuits with a harmonic profile equal to or less than a K factor of 13 without exceeding specified temperature rise. Transformers with K factor of 13 shall be provided, if K factor is not shown on contract drawings. Table below applies to K-13 transformers only.

Harmonic		K-13 (%)
Fundamental		100
3 rd		70
5 th		42
7 th		5
9 th		3
11 th		3
13 th		1
15 th		0.7

17 th		0.6
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PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Installation of transformers shall be in accordance with the NEC, as recommended by the equipment manufacturer and as shown on the drawings.
- B. Install the transformers with adequate clearance at a minimum of 100 mm (4 inches) from wall and adjacent equipment for air circulation to remove the heat produced by transformers.
- C. Install transformers on vibration pads designed to suppress transformer noise and vibrations.
- D. Use flexible metal conduit to enclose the conductors from the transformer to the raceway systems.

3.2 SPARE PARTS

- A. Deliver the following spare parts for the project to the COTR two weeks prior to final inspection:
 - 1. Six stand-off insulators.
 - 2. Six insulated protective caps.
 - 3. One spare set of high voltage fuses for each size fuse used in the project.

3.3 TRAINING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Section 01 00 00 GENERAL REQUIREMENTS.
 - 1. Train Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 8 hours' training.
 - 2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.
 - 3. Test and troubleshoot the system.

- - - E N D - - -

SECTION 26 23 00**LOW-VOLTAGE SWITCHGEAR****PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation, and connection of the low voltage indoor switchgear.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and Wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and outlet boxes.
- E. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Coordination study of overcurrent protection devices.
- F. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL: For metering devices integral to the low-voltage switchgear.
- G. Section 26 11 16, SECONDARY UNIT SUBSTATIONS: Secondary unit substation.
- H. Section 26 25 11, BUSWAYS: Feeder Busways and Fittings.
- I. Section 26 27 13, ELECTRIC METERING: For revenue metering integral to the switchgear.
- J. Section 26 43 13, TRANSIENT-VOLTAGE SURGE SUPPRESSION: For TVSS units integral to the switchgear.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Low-voltage switchgear shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Tests shall be conducted as per UL and ANSI Standards. Factory tests shall be certified.
- B. Thoroughly test the switchgear at the factory with the circuit breakers in the connected position in their cubicles. The factory tests shall be

in accordance with C37.20 and ANSI C37.51 and shall include the following tests:

1. Design Tests
2. Production Tests
3. Conformance Tests

C. The following additional tests shall be performed:

1. Verify that circuit breaker sizes and types correspond to drawings and coordination study.
2. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
3. Confirm correct operation and sequencing of electrical and mechanical interlock systems by attempting closure on locked-open devices, and attempting to open locked-closed devices, and making key exchange with devices operated in off-normal positions.
4. Verify correct barrier and shutter installation and operation.
5. Exercise all active components.
6. Inspect indicating devices for correct operation.
7. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data.
8. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable, or as required if solid-state components or control devices cannot tolerate the applied voltage.
9. If applicable, verify correct function of control transfer relays located in the switchgear with multiple control power sources.
10. Perform phasing checks on double-ended or dual-source switchgear to insure correct bus phasing from each source.

D. Furnish four (4) copies of certified manufacturer's factory test reports to the COTR prior to shipment of the switchgear to ensure that the switchgear has been successfully tested as specified.

1.5 SUBMITTALS

Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:

A. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, temperature rise, wiring and connection diagrams, plan, front, side, and rear elevations, sectional views, bus work, circuit breaker frame sizes, trip and short-circuit rating, long-time, short-time, instantaneous and ground fault settings, coordinated breaker and fuse curves, accessories, and device nameplate data.
3. Show the size, ampere-rating, number of bars per phase and neutral in each bus run (horizontal and vertical), bus spacing, equipment ground bus, and bus material.

B. Manuals:

1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - a. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - b. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
 - c. Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the equipment.
 - d. Approvals will be based on complete submissions of manuals together with shop drawings.
2. Two weeks prior to final inspection, deliver four copies of the final updated maintenance and operating manuals to the COTR.
 - a. The manuals shall be updated to include any information necessitated by shop drawing approval.
 - b. Complete "As Installed" wiring and schematic diagrams shall be included which show all items of equipment and their interconnecting wiring.
 - c. Show all terminal identification.
 - d. Include information for testing, repair, trouble shooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.

- e. Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
 - f. Furnish manuals in loose-leaf binder or manufacturer's standard binder.
- C. Certifications:
- 1. Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - a. Certification by the Contractor that the assemblies have been properly installed, adjusted and tested, including circuit breaker settings.
 - b. Certified copies of all of the factory design and production tests, field test data sheets and reports for the assemblies.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Engineering and Electronic Engineers (IEEE):
- C37.13.....Low Voltage AC Power Circuit Breakers Used in Enclosures
 - C37.20.1.....Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
 - C57.13.....Instrument Transformers
 - C62.41.....Surge Voltage in Low Voltage AC Power Circuits
- C. National Electrical Manufacturers Association (NEMA):
- SG-3.....Low Voltage Power Circuit Breakers.
 - SG-5.....Power Switchgear Assemblies.
- D. National Fire Protection Association (NFPA):
- 70.....National Electrical Code (NEC).
- E. Underwriters Laboratories, Inc. (UL):
- UL 891Dead-Front Switchboards
 - 977.....Safety Fused Power Circuit Devices
 - 1053.....Ground Fault Sensing and Relaying Equipment
 - UL 1558.....Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

PART 2 - PRODUCTS**2.1 GENERAL**

- A. Low voltage switchgear shall be in accordance with IEEE, NEMA, NFPA and UL.
- B. Provide complete switchgear including, but not limited to housing, buses, draw out air circuit breakers, instruments and related transformers, relays fuses and wiring.
- C. Switchgear dimensions shall not exceed the dimensions shown on the drawings.
- D. Manufacturer's nameplate shall include complete ratings of switchgear in addition to date of manufacture.

2.2 HOUSING

- A. Construction: Provide housing of structural or formed steel frame braced to maintain alignment and resist damage during shipment, erection, and by stresses resulting from short circuits. Enclose the frame on all sides, top, and bottom (except cable compartment) with sheet steel covers, doors and panels and equip with interior barriers. Provide rear access panels of the hinged type with provisions for padlocking. Provide ventilating louvers where required to limit the temperature rise of current carrying parts. Provide breakers with hinged covers and cutouts for control mechanism. Protect all openings against entrance of falling dirt, water or foreign matter. Isolate each breaker in its own compartment. Metering transformers and instruments shall be similarly isolated.
- B. Painting: Enclosure shall be thoroughly cleaned, phosphate treated and primed by a phosphate or similar treatment, and followed immediately with a rust-inhibiting paint. Final finish coat shall be the manufacturers standard gray.
- C. Breaker Compartments: The breaker compartments shall include stationary primary contacts, stationary secondary contacts as required, barriers, and rails for the drawout elements.

2.3 BUSES

- A. General: Arrange buses for 3 phase, 4 wire distribution. The phase buses (through bus), neutral bus, and ground bus shall be full capacity and shall extend the entire length of the switchgear. Make provisions for future extensions by means of bolt holes or other approved method. Brace bus to withstand short circuit current available at the particular location.

- B. Material and Size: Buses and connections shall be hard-drawn copper of 98 percent conductivity. Bus size and arrangement shall be such that the temperature rise of the buses shall not exceed IEEE standards. Bus connections to circuit breakers shall be copper. Size feeder busing to the line side of breakers based on IEEE. Bus laminations shall have a minimum of 1/4 inch [6mm] spacing.
- C. Bus Connections: Provide bolted or welded connections. All contact surfaces are of copper. A minimum of two plated bolts per splice or connection is required for nonwelded bus except where physical bus size permits only one bolt; the joint shall include an approved means, other than friction, to prevent turning, twisting, or bending. Bolts shall be torqued to the values recommended by the manufacturer.
- D. Neutral Bus: Provide bare neutral bus mounted on insulated bus supports. Provide neutral disconnect links to permit isolation of the neutral bus from the common ground bus and service entrance conductors.
- E. Ground Bus: Provide an uninsulated 6 mm by 50 mm (1/4 inch by 2 inch) copper equipment ground bus bar the length of the switchgear and secure to each unit frame.
- F. Main Bonding Jumper: An uninsulated 6 mm by 50 mm (1/4 inch by 2 inch) copper bus shall interconnect the neutral and ground buses, when the secondary service equipment is incorporated within the switchgear to establish the system common ground point.

2.4 NAMEPLATES AND MIMIC BUS

- A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 1/2 inch [12mm] engraved lettered nameplates next to each circuit breaker. For Essential Electrical System, provide laminated red phenolic resin with white core with 1/2 inch [12mm] engraved lettered nameplates next to each circuit breaker. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of breakers or on equipment enclosure next to breakers. Mounting nameplates only with adhesive is not acceptable.
- B. Mimic Bus: Provide an approved mimic bus on front of each switchgear assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

2.5 METERING

Refer to Section 26 27 13, ELECTRIC METERING.

2.6 SPACE FOR FUTURE

Where "provision for", "future", or "space" is noted on drawings, equip the compartment with rails, mounting brackets, supports, bus connections, and any appurtenances necessary for ready insertion of a future breaker. A blank door shall close off the front of the compartment. Design buses for the breaker ampere rating as indicated on the drawings.

2.7 BREAKER REMOVAL EQUIPMENT

Furnish a portable elevating carriage or permanent top-mounted device for installation and removal of circuit breakers.

2.8 CONTROL WIRING

Switchgear control wiring shall be 600 volt Class B stranded SIS. Install all control wiring complete at the factory, adequately bundled and protected. All conductors size No. 8 and smaller, all conductors across hinges, and all conductors for interconnection between shipping units shall be Class C stranded. Size conductors in accordance with the NEC. Provide separate control circuit fuses in each breaker compartment and locate for ease of access and maintenance. Control power transformers to be automatically transferred to bus where source is present.

2.9 LOW VOLTAGE POWER CIRCUIT BREAKERS

- A. General: Circuit breakers shall be dead front, drawout, stored energy type with solid state trip devices. Arcing contacts shall be renewable. Circuit breakers shall be UL listed (Category PAQX).
- B. Rating: Circuit breakers shall be 3 pole, 600 volts AC and below, 60 cycle with indicated frame size, trip rating and system voltage. Breakers shall have 30 cycle short time current ratings. Tie breaker shall be 4 pole, 600 V AC and below, 60 cycle with indicated frame size, trip rating and system voltage.
- C. Drawout Mounting: Provide a racking mechanism to position and hold the breaker in the connected, test, or disconnected position. Provide an interlock to prevent movement of the breaker into or out of the connected position unless the breaker is tripped open.
- D. Trip Devices: Breakers shall be electrically and mechanically trip free and shall have trip devices in each pole. Unless otherwise indicated, each breaker shall have overcurrent, short-circuit and integral zero

sequence ground fault trip main circuit devices. Trip devices shall be of the solid state type with adjustable pick-up settings, with both long time and short time elements, and integral trip unit testing provisions. Devices shall have time-delay band adjustment of minimum, intermediate, and maximum setting. Long-time delay element shall have inverse time characteristics. Main circuit breakers shall have short-time trips, in lieu of instantaneous trips. Final settings, of pick-up and time bands shall be as reflected by the Electric System Protective Device Study.

- E. Position Indicator: Provide a mechanical indicator visible from the front of the unit to indicate whether the breaker is open or closed.
- F. Trip Button: Equip each breaker with a mechanical trip button accessible from the front of the door, which shall permit tripping of the breaker.
- G. Padlocking: Provisions shall be included for padlocking the breaker in the open position.
- H. Operation: Unless otherwise indicated on the drawings, breakers 1600 ampere frame size and less shall be manually operated. Breakers larger than 1600 ampere frame size shall be electrically operated.

2.10 DUAL SOURCE, WITH TIE, OPEN TRANSITION AUTOMATIC TRANSFER CONTROL SYSTEM

- A. Where indicated on the drawings, provide an automatic transfer control system for control of three circuit breakers. The logic of the transfer control system functions shall be provided via a microprocessor. The set points shall be field adjustable without the use of special tools.
- B. The transfer control system shall be provided with a local display. The display shall show the status of the system as it is operating. When timers are functioning, the display shall show the timer counting down. All time delays shall be capable of being set from the front of the display using a timer setting screen.
- C. The transfer control system includes the following features:
 - 1. Time delay to transfer on loss of Source 1, adjustable.
 - 2. Time delay to transfer on loss of Source 2, adjustable.
 - 3. Time delay re-transfer to Source 1, adjustable.
 - 4. Time delay re-transfer to Source 2, adjustable.
 - 5. Time delay neutral (main and tie open), adjustable.
 - 6. The local system display shall show the following: Main- Tie- Main one line diagram: main and tie breaker status (open, closed, tripped, out of cell); readout marked "Source 1" and "Source 2" to

indicate that respective source voltages are available;
automatic/manual mode select pushbutton; pushbuttons for manual
breaker control; and alarm information (loss of source, breaker
trip).

D. Sequence of Operation - Automatic Mode

1. Under normal conditions, the main breakers are closed and the tie breaker is open.
2. Upon phase loss or loss of phase-to-phase voltage of either utility source to between 80% and 100% of nominal, and after a time delay, adjustable from 1 to 60 seconds to override momentary dips and outages the transfer control system shall open the affected main breaker and close the tie breaker.
3. When normal voltage has been restored after a time delay, adjustable from 10 to 600 seconds (to ensure the integrity of the source), the transfer control system shall open the tie breaker. The transfer control system shall have an adjustable neutral position timer (0-10 seconds) to allow voltage to decay sufficiently before the affected main breaker is then closed (open transition retransfer).
4. If Source 2 should fail while carrying the load, transfer to Source 1 shall be made instantaneously upon restoration of Source 1 to satisfactory conditions.
5. If both sources should fail simultaneously, no action shall be taken.
6. If the main or tie breakers trip due to a fault, the transfer control system shall be reset to manual mode and manual operation of that breaker shall be prevented until its overcurrent trip switch is reset.

E. Sequence of Operation - Manual Mode

1. While in manual mode, breakers shall be capable of being opened and closed using control switches or pushbuttons on the transfer control system display. Electrical interlocking shall be provided to prevent the closing of both mains and the tie simultaneously.

F. Provide a control power transformer for each source with control power transfer scheme.

G. Provide electrically operated main and tie circuit breakers.

H. Provide a programmable logic controller with 24 volts dc ride-through power supply.

I. Provide an industrial display panel.

2.11 ACCESSORY SET

- A. Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
 - 1. Racking handle to manually move circuit breaker between connected and disconnected positions.
 - 2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
 - 3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
- B. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install the switchgear in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor switchgear to the slab with plated 1/2 inch [12.5mm] minimum anchor bolts, or as recommended by the manufacturer.
- C. Interior Location. Mount switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 4 inches [100mm] thick. The top of the concrete slab shall be approximately 4 inches [100mm] above finished floor. Edges above floor shall have 1/2 inch [15mm] chamfer. The slab shall be of adequate size to project at least 100 mm 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches [75mm] above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
 - 1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Confirm correct application of manufacturer's recommended lubricants.
 - d. Verify appropriate anchorage, required area clearances, and correct alignment.

- e. Verify that circuit breaker sizes and types correspond to approved shop drawings.
 - f. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
 - g. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - h. Clean switchgear.
 - i. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - j. Verify correct shutter installation and operation.
 - k. Exercise all active components.
 - l. Verify the correct operation of all sensing devices, alarms, and indicating devices.
 - m. Verify that vents are clear.
 - n. Inspect control power transformers.
2. Electrical Tests
- a. Perform insulation-resistance tests on each bus section.
 - b. Perform overpotential tests.
 - c. Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.
 - d. Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the switchgear is in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device.

3.4 INSTRUCTION

Furnish the services of a factory certified instructor for one 4 hour period for instructing personnel in the operation and maintenance of the switchgear and related equipment on the date requested by the COTR.

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SECTION 26 24 11
DISTRIBUTION SWITCHBOARDS

PART 1 - GENERAL**1.1 DESCRIPTION**

This section specifies the furnishing, installation, and connection of the distribution switchboards.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for Personnel Safety and to provide a low impedance path for possible fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and outlet boxes.
- E. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Coordination study of overcurrent protection devices.
- F. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL: For metering devices integral to the distribution switchboards.
- G. Section 26 11 16, SECONDARY UNIT SUBSTATIONS: Switchboards as part of secondary unit substation.
- H. Section 26 25 11, BUSWAYS: Feeder busway and fittings.
- I. Section 26 27 13, ELECTRIC METERING: For revenue metering devices integral to the distribution switchboards.
- J. Section 26 43 13, TRANSIENT-VOLTAGE SURGE SUPPRESSION: TVSS equipment for distribution switchboards.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Distribution switchboards shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Tests shall be conducted as per NEMA PB 2 and UL 891. Factory tests shall be certified.
- B. The following additional tests shall be performed:
 - 1. Verify that circuit breaker sizes and types correspond to drawings and coordination study.

2. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 3. Exercise all active components.
 4. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data.
 5. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable, or as required if solid-state components or control devices cannot tolerate the applied voltage.
 6. If applicable, verify correct function of control transfer relays located in the switchboard with multiple control power sources.
 7. Perform phasing checks on double-ended or dual-source switchboards to insure correct bus phasing from each source.
- C. Furnish four (4) copies of certified manufacturer's factory test reports to the COTR prior to shipment of the switchboards to ensure that the switchboards have been successfully tested as specified.

1.5 SUBMITTALS

Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:

A. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, temperature rise, wiring and connection diagrams, plan, front, side, and rear elevations, sectional views, bus work, circuit breaker frame sizes, trip and short-circuit rating, long-time, short-time, instantaneous and ground fault settings, coordinated breaker and fuse curves, accessories, and device nameplate data.
3. Show the size, ampere-rating, number of bars per phase and neutral in each bus run (horizontal and vertical), bus spacing, equipment ground bus, and bus material.

B. Manuals:

1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

- a. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - b. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
 - c. Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the equipment.
 - d. Approvals will be based on complete submissions of manuals together with shop drawings.
2. Two weeks prior to final inspection, deliver four copies of the final updated maintenance and operating manuals to the COTR.
 - a. The manuals shall be updated to include any information necessitated by shop drawing approval.
 - b. Complete "As Installed" wiring and schematic diagrams shall be included which show all items of equipment and their interconnecting wiring.
 - c. Show all terminal identification.
 - d. Include information for testing, repair, trouble shooting, assembly, disassembly, and recommended maintenance intervals.
 - e. Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.
 - f. Furnish manuals in loose-leaf binder or manufacturer's standard binder.
- C. Certifications:
1. Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - a. Certification by the Contractor that the assemblies have been properly installed, adjusted and tested, including circuit breakers settings.
 - b. Certified copies of all of the factory design and production tests, field test data sheets and reports for the assemblies.

1.6 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

- A. Institute of Engineering and Electronic Engineers (IEEE):
- C37.13.....Low Voltage AC Power Circuit Breakers Used in Enclosures

- C57.13.....Instrument Transformers
- C62.41.....Surge Voltage in Low Voltage AC Power Circuits
- C62.45.....Surge Testing for Equipment connected to Low-Voltage AC Power Circuits
- B. National Electrical Manufacturer's Association (NEMA):
 - PB-2.....Dead-Front Distribution Switchboards.
 - PB-2.1.....Instructions for Proper Handling, Installation, Operation, and Maintenance of Switchboards
 - AB-1.....Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures
- C. National Fire Protection Association (NFPA):
 - 70.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
 - 67.....Panelboards
 - 489.....Molded Case Circuit Breakers and Circuit Breakers Enclosures
 - 891.....Dead-Front Switchboards
 - 1283.....Electromagnetic Interference Filters
 - 1449.....Transient Voltage Surge Suppressors

PART 2 - PRODUCTS

2.1 GENERAL

- A. Switchboards shall be in accordance with UL, NEMA, NEC, IEEE, and as shown on the drawings.
- B. Switchboards shall be provided complete, ready for operation including, but not limited to housing, buses, circuit breakers, instruments and related transformers, fuses, and wiring.
- C. Switchboard dimensions shall not exceed the dimensions shown on the drawings.
- D. Manufacturer's nameplate shall include complete ratings of switchboard in addition to the date of manufacture.

2.2 BASIC ARRANGEMENT

- A. Type I: Switchboard shall be front accessible with the following features:
 - 1. Device mounting:
 - a. Main breaker: Individually mounted and compartmented or group mounted with feeder breakers.
 - b. Feeder breakers: Group mounted.
 - 2. Section alignment: As shown on the drawings.
 - 3. Accessibility:
 - a. Main section line and load terminals: Front and side.

- b. Distribution section line and load terminals: Front.
- c. Through bus connections: Front and end.
- 4. Bolted line and load connections.
- 5. Full height wiring gutter covers for access to wiring terminals.
- 6. Short Circuit Current Rating: 65,000 amperes rms symmetrical, minimum, or as shown on the drawings, whichever is higher.

2.3 HOUSING

- A. Provide a completely enclosed, free standing, steel enclosure not less than the gage required by the ANSI and UL standards. The enclosure is to consist of the required number of vertical sections bolted together to form one metal enclosed rigid switchboard. The sides, top and rear shall be covered with removable screw on sheet steel plates.
- B. Provide ventilating louvers where required to limit the temperature rise of current carrying parts. All openings shall be protected against entrance of falling dirt, water, or foreign matter.
- C. Enclosure shall be thoroughly cleaned, phosphate treated, and primed with rust-inhibiting paint. Final finish coat to be the manufacturers standard gray. Provide a quart of finish paint for touch-up purposes.

2.4 BUSES

- A. General: Buses shall be arranged for 3 phase, 4 wire distribution. Main phase buses (through bus), full size neutral bus, and ground bus shall be full capacity the entire length of the switchboard. Provide for future extensions by means of bolt holes or other approved method. Brace the bus to withstand the available short circuit current at the particular location and as shown on the drawings. No magnetic material shall be used between buses to form a magnetic loop.
- B. Material and Size: Buses and connections shall be hard drawn copper of 98 percent conductivity. Bus temperature rise shall not exceed 65 degrees C (149 degrees F). Section busing shall be sized based on UL and NEMA Switchboard Standards.
- C. Bus Connections: All contact surfaces shall be copper. Provide a minimum of two plated bolts per splice. Where physical bus size permits only one bolt, provide a means other than friction to prevent turning, twisting or bending. Torque bolts to the manufacturer's recommended values.
- D. Neutral Bus: Provide bare or plated bus and mount on insulated bus supports. Provide neutral disconnect link to permit isolation of neutral bus from the common ground bus and service entrance conductors.
- E. Ground Bus: Provide an uninsulated 6 mm by 50 mm (1/4 inch by 2 inch) copper equipment ground bus bar sized per UL 891 the length of the switchboard and secure at each section.

2.5 TRANSIENT VOLTAGE SURGE SUPPRESSION

Refer to Section 26 43 13, TRANSIENT-VOLTAGE SURGE SUPPRESSION.

2.6 METERING

Refer to Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL.

2.7 NAMEPLATES AND MIMIC BUS

- A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 1/2 inch [12mm] engraved lettered nameplates next to each circuit breaker. For Essential Electrical System, provide laminated red phenolic resin with white core with 1/2 inch [12mm] engraved lettered nameplates next to each circuit breaker. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of breakers or on equipment enclosure next to breakers. Mounting nameplates only with adhesive is not acceptable.
- B. Mimic Bus: Provide an approved mimic bus on front of each switchboard assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

2.8 PROVISION FOR FUTURE

Where "provision for", "future", or "space" is noted on drawings, the space shall be equipped with bus connections to the future overcurrent device with suitable insulation and bracing to maintain proper short circuit rating and physical clearance. Provide buses for the ampere rating as shown for the future device.

2.9 BREAKER REMOVAL EQUIPMENT

Where draw out circuit breakers are provided, furnish a portable elevating carriage or switchboard permanent top mounted device for installation and removal of the breakers.

2.10 CONTROL WIRING

Control wiring shall be 600 volt class B stranded SIS. Install all control wiring complete at the factory adequately bundled and protected. Wiring across hinges and between shipping units shall be Class C stranded. Size in accordance with NEC. Provide control circuit fuses.

2.11 MAIN CIRCUIT BREAKERS

- A. Type I Switchboard: Provide UL listed and labeled molded case circuit breakers in accordance with NEC and as shown on the drawings. Circuit breakers shall be the solid state adjustable trip type.

1. Trip units shall have field adjustable tripping characteristics as follows:
 - a. Ampere setting (continuous).
 - b. Long time band.
 - c. Short time trip point.
 - d. Short time delay.
 - e. Instantaneous trip point.
 - f. Ground fault trip point.
 - g. Ground fault trip delay.
2. Trip settings shall be as indicated on the drawings. Final settings shall be as shown on the electrical system protective device study.
3. Breakers, which have same rating, shall be interchangeable with each other.

2.12 FEEDER CIRCUIT BREAKERS

- A. Provide UL listed and labeled molded case circuit breakers, in accordance with the NEC, as shown on the drawings, and as herein specified.
- B. Adjustable Trip Molded Case Circuit Breakers:
 1. Provide molded case, solid state adjustable trip type circuit breakers.
 2. Trip units shall have field adjustable tripping characteristics as follows:
 - a. Ampere setting (continuous).
 - b. Long time band.
 - c. Short time trip point.
 - d. Short time delay.
 - e. Instantaneous trip point.
 - f. Ground fault trip point.
 - g. Ground fault trip delay.
 3. Trip settings shall be as indicated on the drawings. Final settings shall be shown on the electrical system protective device study.
 4. Breakers, which have same rating, shall be interchangeable with each other.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the switchboard in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor switchboard to the slab with plated 1/2 inch [12.5mm] minimum anchor bolts, or as recommended by the manufacturer.

- C. Exterior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 8 inches [200mm] thick, reinforced with a 6 by 6 inch [150 by 150mm] No. 6 mesh placed uniformly 4 inches [100mm] from the top of the slab. Slab shall be placed on a 6 inch [150mm] thick, well-compacted gravel base. The top of the concrete slab shall be approximately 4 inches [100mm] above the finished grade. Edges above grade shall have 1/2 inch [12.5mm] chamfer. The slab shall be of adequate size to project at least 8 inches [200mm] beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches [75mm] above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- D. Interior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 4 inches [100mm] thick. The top of the concrete slab shall be approximately 4 inches [100mm] above finished floor. Edges above floor shall have 1/2 inch [12.5mm] chamfer. The slab shall be of adequate size to project at least 8 inches [200mm] beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches [75mm] above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Confirm correct application of manufacturer's recommended lubricants.
 - d. Verify appropriate anchorage, required area clearances, and correct alignment.
 - e. Verify that circuit breaker sizes and types correspond to approved shop drawings.
 - f. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.

- g. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - h. Clean switchboard.
 - i. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - j. Verify correct shutter installation and operation.
 - k. Exercise all active components.
 - l. Verify the correct operation of all sensing devices, alarms, and indicating devices.
 - m. If applicable, verify that vents are clear.
 - n. If applicable, inspect control power transformers.
2. Electrical Tests
- a. Perform insulation-resistance tests on each bus section.
 - b. Perform overpotential tests.
 - c. Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.
 - d. Perform phasing check on double-ended switchboard to ensure correct bus phasing from each source.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the switchboard is in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device.

3.4 INSTRUCTION

Furnish the services of a factory certified instructor for one 4 hour period for instructing personnel in the operation and maintenance of the switchboard and related equipment on the date requested by the COTR.

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SECTION 26 24 16**PANELBOARDS****PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation and connection of panelboards.

1.2 RELATED WORK

- A. Section 09 91 00, PAINTING: Identification and painting of panelboards.
- B. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY:
Requirements for the over current protective devices to be installed to ensure proper equipment and personnel protection.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.
- D. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, wiring diagrams accessories and weights of equipment. Complete nameplate data including manufacturer's name and catalog number.
- C. Certification: Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - 1. Certification that the material is in accordance with the drawings and specifications has been properly installed, and that the loads are balanced.

1.4 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

- A. National Electrical Manufacturers Association (NEMA):

PB-1-2006.....Panelboards

AB-1-2002.....Molded Case Circuit Breakers, Molded Case
Switches and Circuit Breaker Enclosures

B. National Fire Protection Association (NFPA):

70-2005National Electrical Code (NEC)

70E-2004.....Standard for Electrical Life Safety in the
Workplace

C. Underwriters Laboratories, Inc. (UL):

50-2003.....Enclosures for Electrical Equipment

67-2003.....Panel boards

489-2006.....Molded Case Circuit Breakers and Circuit
Breaker Enclosures

PART 2 - PRODUCTS

2.1 PANELBOARDS

- A. Panelboards shall be in accordance with UL, NEMA, NEC, and as shown on the drawings.
- B. Panelboards shall be standard manufactured products. All components of the panelboards shall be the product and assembly of the same manufacturer. All similar units of all panelboards to be of the same manufacturer.
- C. All panelboards shall be hinged "door in door" type with:
 - 1. Interior hinged door with hand operated latch or latches as required to provide access to circuit breaker operating handles only, not to energized ports.
 - 2. Outer hinged door shall be securely mounted to the panelboard box with factory bolts, screws, clips or other fasteners requiring a tool for entry, hand operated latches are not acceptable.
 - 3. Push inner and outer doors shall open left to right.
- D. All panelboards shall be completely factory assembled with molded case circuit breakers. Include one-piece removable, inner dead front cover independent of the panelboard cover.
- E. Panelboards shall have main breaker or main lugs, bus size, voltage, phase, top or bottom feed, and flush or surface mounting as scheduled on the drawings.

F. Panelboards shall conform to NEMA PB-1, NEMA AB-1 and UL 67 and have the following features:

1. Nonreduced size copper bus bars, complete with current ratings as shown on the panel schedules connection straps bolted together and rigidly supported on molded insulators.
2. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type. Single-phase, three-wire panelboard busing shall be such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Three-phase, four-wire busing shall be such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two-or three-pole breakers can be installed at any location. Current-carrying parts of the bus assembly shall be plated. Mains ratings shall be as shown.
3. Mechanical lugs furnished with panelboards shall be cast, stamped or machined metal alloys of sizes suitable for the conductors indicated to be connected thereto.
4. Neutral bus shall be 200%rated, mounted on insulated supports.
5. Grounding bus bar equipped with screws or lugs for the connection of grounding wires.
6. Buses braced for the available short circuit current, but not less than 22,000 amperes symmetrical for 120/208 volt and 120/240 volt panelboards, and 14,000 amperes symmetrical for 277/480-volt panelboards.
7. Branch circuit panels shall have buses fabricated for bolt-on type circuit breakers.
8. Protective devices shall be designed so that they can be easily replaced.
9. Where designated on panel schedule "spaces", include all necessary bussing, device support and connections. Provide blank cover for each space.
10. In two section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the line side of main lugs only, or through-feed lugs for main breaker type panels, and with cable connections to the second section. Panelboard sections with tapped bus or crossover bus are not acceptable.

11. Series rated panelboards are not permitted.

2.2 CABINETS AND TRIMS

A. Cabinets:

1. Provide galvanized steel cabinets to house panelboards. Cabinets for outdoor panels shall be factory primed and suitably treated with a corrosion-resisting paint finish meeting UL 50 and UL 67.
2. Cabinet enclosure shall not have ventilating openings.
3. Cabinets for panelboards may be of one-piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.
4. Provide door-in-door trim with 3 three point latching on both hinged trim and door trim. No tools shall be required to install or remove trim.

2.3 MOLDED CASE CIRCUIT BREAKERS FOR PANELBOARDS

- ### **A. Breakers shall be UL 489 listed and labeled, in accordance with the NEC, as shown on the drawings, and as specified.**

- ### **B. Circuit breakers in panelboards shall be bolt on type on phase bus bar or branch circuit bar.**

1. Molded case circuit breakers for lighting and appliance branch circuit panelboards shall have minimum interrupting rating as indicated but not less than:
 - a. 120/208 Volt Panelboard: 22,000 amperes symmetrical.
 - b. 120/240 Volt Panelboard: 22,000 amperes symmetrical.
 - c. 277/480 Volt Panelboard: 14,000 amperes symmetrical.
2. Molded case circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for 100-ampere frame or less. Magnetic trip shall be adjustable from 3X to 10X for breakers with 600 ampere frames and higher. Breaker trip setting shall be set in the field based on the approved protective device study as specified in Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.

- ### **C. Breaker features shall be as follows:**

1. A rugged, integral housing of molded insulating material.
2. Silver alloy contacts.
3. Arc quenchers and phase barriers for each pole.
4. Quick-make, quick-break, operating mechanisms.

5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
6. Electrically and mechanically trip free.
7. An operating handle which indicates ON, TRIPPED, and OFF positions.
 - a. Line connections shall be bolted.
 - b. Interrupting rating shall not be less than the maximum short circuit current available at the line terminals as shown on the electrical system protective device study as required in Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.
8. An overload on one pole of a multipole breaker shall automatically cause all the poles of the breaker to open.
9. Shunt trips shall be provided where indicated
10. For circuit breakers being added to existing panelboards, coordinate the breaker type with existing panelboards. Modify the panel directory.

2.4 SEPARATELY ENCLOSED MOLDED CASE CIRCUIT BREAKERS

- A. Where separately enclosed molded case circuit breakers are shown on the drawings, provide circuit breakers in accordance with the applicable requirements of those specified for panelboards.
- B. Enclosures are to be of the NEMA types shown on the drawings. Where the types are not shown, they are to be the NEMA type most suitable for the environmental conditions where the breakers are being installed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the Manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Locate panelboards so that the present and future conduits can be conveniently connected. Coordinate the sizes of cabinets with designated closet space.
- C. In accordance with Section 09 91 00, PAINTING, paint the panelboard system voltage, and feeder sizes as shown on the riser diagram in 1 inch block lettering on the inside cover of the cabinet door. Paint the words "LIFE SAFETY BRANCH", "CRITICAL BRANCH", or "EQUIPMENT SYSTEM" as applicable and the panel designation in one inch block letters on the outside of the cabinet doors.
- D. Install a typewritten schedule of circuits in each panelboard after being submitted to and approved by the COTR. Schedules, after approval,

shall be typed on the panel directory cards and installed in the appropriate panelboards, incorporating all applicable contract changes pertaining to that schedule. Include the room numbers and items served on the cards.

- E. Mount the panelboard fully aligned and such that the maximum height of the top circuit breaker above finished floor shall not exceed 1980 mm (78 inches). For panelboards that are too high, mount panelboard so that the bottom of the cabinets will not be less than 150 mm (6 inches) above the finished floor.
- F. For panelboards located in areas accessible to the public, paint the exposed surfaces of the trims, doors, and boxes with finishes to match surrounding surfaces after the panelboards have been installed.
- G. Directory-card information shall be typewritten to indicate outlets, lights, devices, and equipment controlled and final room numbers served by each circuit and shall be mounted in holders behind protective covering.
- H. Where new panels are to be installed in existing backboxes, backboxes shall have rust and scale removed from inside. Paint inside of backboxes with rust preventive paint before the new panel interior is installed. Provide new trim and doors for these panels. Covers shall fit tight to the box with no gaps between the cover and the box.
- I. Provide ARC flash identification per NFPA 70E.

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SECTION 26 27 13
ELECTRIC METERING**PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation and connection of an electric metering system installed on electrical equipment such as medium voltage switchgear and low voltage switchgear, switchboards, distribution panels and/or branch circuit panelboards of both the normal and essential power systems.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage cable.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.
- D. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL: Power monitoring and control equipment.
- E. Section 26 11 16, SECONDARY UNIT SUBSTATIONS: Unit secondary substation.
- F. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Medium voltage switchgear.
- G. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: Secondary distribution switchgear.
- H. Section 26 24 11, DISTRIBUTION SWITCHBOARDS: Secondary distribution switchboards.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:

- A. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include devices, locations, connections, conduit runs, wiring type, details, and attachments to other work.

3. One line diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components.

B. Manuals:

1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - a. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - b. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
 - c. Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the equipment.
 - d. Approvals will be based on complete submissions of manuals together with shop drawings.
2. Two weeks prior to final inspection, deliver four copies of the final updated maintenance and operating manuals to the COTR.
 - a. The manuals shall be updated to include any information necessitated by shop drawing approval.
 - b. Complete "As Installed" wiring and schematic diagrams shall be included which show all items of equipment and their interconnecting wiring.
 - c. Show all terminal identification.
 - d. Include information for testing, repair, trouble shooting, assembly, disassembly, and recommended maintenance intervals.
 - e. Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.
 - f. Furnish manuals in loose-leaf binder or manufacturer's standard binder.

C. Certifications:

1. Two weeks prior to final inspection, submit four copies of the following to the COTR:

- a. Certification by the Contractor that the assemblies have been properly installed, adjusted and tested.
- b. Certified copies of all factory design and production tests, and field test data sheets and reports for the assemblies.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - IEEE C2.....(2007; Errata 2007) National Electrical Safety Code
 - IEEE C37.90.1.....(2002; Errata 2003) Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
 - IEEE C57.13.....(1993; R 2003) Standard Requirements for Instrument Transformers
 - IEEE Std 100.....(2000) The Authoritative Dictionary of IEEE Standards Terms
- C. National Electrical Manufacturers Association (NEMA):
 - NEMA C12.18.....(2006) Protocol Specification for ANSI Type 2 Optical Port
 - NEMA C12.20.....(2002) Electricity Meter - 0.2 and 0.5 Accuracy Classes
 - NEMA C62.61.....(1993) Gas Tube Surge Arrestors on Wire Line Telephone Circuits
- D. National Fire Protection Association (NFPA):
 - 70.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 PHYSICAL AND COMMON REQUIREMENTS

- A. Power meter shall be panel-mounted design. Meters shall be semi-flush, back-connected, dustproof, draw-out switchboard type. Meters shall be of a type that can be withdrawn through approved sliding contacts from fronts of panels or doors without opening current-transformer secondary circuits, disturbing external circuits, or requiring disconnection of any meter leads. Necessary test devices shall be incorporated within each meter and shall provide means for testing either from an external source of electric power or from associated instrument transformers or bus voltage. All current transformers shall be wired to shorting type terminal blocks.

- B. Use Class 200 meters for direct current reading without current transformers.
- C. Meter shall be a Class 20, transformer rated design.
- D. Meter shall be rated for use at temperature from -40 degrees Centigrade to +70 degrees Centigrade.
- E. Meter shall have NEMA 3R enclosure for surface mounting.
- F. Surge withstand shall conform to IEEE C37.90.1.

2.2 VOLTAGE REQUIREMENTS

- A. Meter shall be capable of connection to the service voltage phases and magnitude being monitored.
- B. Meter shall accept independent voltage inputs from each phase. Meter shall be auto-ranging over the full range of input voltages.
- C. Voltage input shall be optically isolated to 2500 volts DC from signal and communications outputs.
- D. Transformer shall conform to IEEE C57.13 and the following requirements.
 - 1. Type: Dry type, of two-winding construction.
 - 2. Weather: Outdoor or Indoor rated for the application.
 - 3. Frequency: Nominal 60Hz.

2.3 CURRENT REQUIREMENTS

- A. Meter shall accept independent current inputs from each phase. Current transformer shall be installed with a full load rating as shown in the schedule.
- B. Single ratio current transformer shall have an Accuracy Class of 0.6 with a maximum error of +/- 0.6% at 5.0 amps.
- C. Current transformer shall have:
 - 1. Insulation Class: All 600 volt and below current transformers shall be rated 10 KV BIL. Current transformers for 2400 and 4160 volt service shall be rated 25 KV BIL.
 - 2. Frequency: Nominal 60Hz.
 - 3. Burden: Burden class shall be selected for the load.
 - 4. Phase Angle Range: 0 to 60 degrees.
- D. Meter shall accept current input from standard instrument transformers.
- E. Current inputs shall have a continuous rating in accordance with IEEE C57.13.
- F. Multi-ratio current transformer where indicated shall have a top range equal to or greater than the actual load. The Contractor shall be responsible for determining the actual ratio of each transformer.

2.4 ELECTRICAL MEASUREMENTS

Power meter shall measure and report the following quantities:

- A. Kilowatt-hours of consumption, cumulative.

- B. Kilowatts of demand, peak average over a selectable demand interval between 5 and 60 minutes (typically 15 minutes).
- C. Reactive power, measured over the same interval as the peak kW reading.
- D. Power factor, measured over the same interval as the peak kW reading.
- E. Time of use consumption, kilowatt-hours recorded separately for each period set by programming into the meter. Time periods shall be capable of being changed without removal from service. The meter shall internally record and store Time of Use data.
 - 1. Four (4) minimum TOU Rates (Registers)
 - 2. Twenty (20) Year Calendar
 - 3. [Two (2)] minimum seasons per year
- F. Interval recording, kilowatt-hours shall be recorded for each 15 minute interval and shall accumulate for 30 days. Memory for recording the interval readings shall be internal to the meter and ANSI C12.19 compliant. Meter shall provide time-stamped readings for every measured parameter.
- G. Meter readings shall be true RMS.

2.5 METER ACCURACY

Power meter shall meet NEMA C12.20 for Class 0.2 and IEC 62053-22 accuracy requirements. Power meter accuracy shall be revenue grade, +/- 0.3%. Accuracies shall be measured as percent of reading at standard meter test points.

2.6 DISPLAY, OUTPUT AND READING CAPABILITIES

- A. The meter will have a face display plate and shall display every electrical parameter indicated to be recorded. Meters shall not be required to indicate interval data collected in a data logger with a communications output feature. Peak values, instantaneous and cumulative values shall be displayed.
- B. Meter shall include output option for pulse output.

2.7 COMMUNICATIONS METHODS

- A. Optical Port: The optical port shall communicate with a hand-held reading device according to the following requirements.
 - 1. Communications standards: NEMA C12.18, MV90 protocol, NEMA C12.20.
 - 2. Read operations: Current kWh values, demand (kW) values since last reset, last reset value, meter status, load profile.
 - 3. Write operations: Meter setup.
- B. Serial Port: Provide onboard RS232 serial port for connection to modem module where required in this specification.
- C. Ethernet: For those meters using the Ethernet, logged information shall be sent using open standard Internet Protocols.

1. On-board Ethernet port support: HTTP, SMTP, Modbus.
2. Distribute stored data by on-board web server.

2.8 COMMUNICATIONS PROTOCOLS AND METHODS

Communications protocols and methods shall be native to the meter.
Provide communications module(s) as required to accomplish the following.

- A. Meter shall have a port that can be configured as a 10/100 Base-T port.
A communication module that converts serial RS232 or RS485 to Ethernet will be acceptable.
- B. Meter shall be equipped with one pulse output channel that can be configured for operation as KYZ pulse output.

2.9 SPARE PARTS

Provide spare parts as follows:

- A. Power meter - two for each type used.
- B. Current transformer - three for each type used.
- C. Potential transformer - three for each type used.
- D. Communications module - one for each type used.
- E. Protocol module - one for each type used.
- F. Other electronic and power components - one for each type used.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Meter shall be mounted at location shown on drawings.
- B. PTs (if required for proper voltage range) and CTs shall be physically connected to the service entrance cables inside the service entrance disconnect enclosure.

3.2 DISCONNECTING SWITCHES

- A. Disconnecting wiring blocks shall be provided between the current transformer and the meter. A shorting mechanism shall be built into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. The wiring blocks shall be located where they are accessible without the necessity of disconnecting power to the transformer. For multi-ratio current transformers, provide a shorting block from each tap to the common lead.
- B. Voltage-monitoring circuits shall be equipped with disconnect switches to isolate the meter base or socket from the voltage source.

3.3 METER PROGRAMMING

- A. Power meter shall be programmable by software supplied by the meter manufacturer.
- B. Software shall allow the user to configure the meter, troubleshoot meter, query and display meter parameters and configuration data and stored values.
- C. Meter firmware shall be upgradeable through one of the communications ports without removing the unit from service.

3.4 ACCEPTANCE CHECKS AND TESTS

- A. Visual and mechanical inspection:
 - 1. Compare equipment nameplate data with specification and approved shop drawings.
 - 2. Inspect physical and mechanical condition.
 - 3. Verify grounding of metering enclosure.
 - 4. Verify that the CT ratio and the PT ratio are properly included in the meter multiplier or the programming of the meter.

5. Verify that correct multiplier has been placed on face or meter where applicable.

B. Electrical tests:

1. Prior to system acceptance, the Contractor will demonstrate and confirm the meter is properly wired and is displaying correct and accurate electrical information.

3.5 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the meters are in good operating condition and are displaying and storing correct and accurate electrical information.

3.6 INSTRUCTION

- A. The Contractor shall conduct a training course for meter configuration, operation, and maintenance of the system as specified. The training shall be oriented for all components and systems installed under this contract. The training shall include:
1. Physical layout of each piece of hardware.
 2. Meter configuration, troubleshooting and diagnostics procedures.
 3. Repair instructions.
 4. Preventive maintenance procedures and schedules.
 5. Testing and calibration procedures.
 6. Use of metering software.

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SECTION 26 27 20
MODULAR WIRING SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Modular Wiring System - Distribution:
 - 1. Standard Capacity Power Distribution Modules
 - 2. Conversion Modules
 - 3. Open Power Cables - PowerMate Home Run Cables
 - 4. Closed Power Cables - PowerMate Jumper Cables
 - 5. Coupler Modules
 - 6. T-Connects
 - 7. 3-Way Splitter Modules
- B. Modular Wiring System - Workstation Termination:
 - 1. Power/Voice/Data Raised Access Floor Boxes (PVD Box, AFB).

1.2 RELATED SECTIONS

- A. Section 09 69 00 - Access Flooring.
- B. Section 12 59 00 - Systems Furniture.
- C. Section 26 05 00 - Basic Electrical Materials and Methods (Common Work Results for Electrical).
- D. Section 26 05 00 - Wiring Methods (Common Work Results for Electrical).
- E. Section 26 27 00 - Low-Voltage Distribution (Low-Voltage Distribution Equipment).

1.3 REFERENCES

- A. International Mechanical Code, Section 602.2.1.4 - Combustible Electrical Equipment in Plenums.
- B. MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
- C. NFPA 70 - National Electrical Code, (NEC).
 - 1. Article 210.19(A) FPN No. 4. - Voltage Drop
 - 2. Article 300.22(C) - Other Space Used for Environmental Air.
 - 3. Article 604 - Manufactured Wiring Systems.
- D. UL 183 - Manufactured Wiring Systems.
- E. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
- F. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air Handling Spaces.

1.4 SYSTEM DESCRIPTION

- A. Modular power system shall ensure efficient electrification and delivery of power from power panels to workstations or equipment at any location. System shall be prefabricated, flexible and totally relocatable, with

true plug-and-play modularity, for electrification of power receptacles located in workstations and other common areas of the building. System shall be designed and approved for use below raised access floor systems and other air handling spaces per NEC Article 300.22(C).

- B. Modular wiring system is based on zone wiring requirements. Power distribution is achieved below a raised access floor through the use of multi-conductor open power cables run from circuit breaker panel to prewired power distribution modules. This method of wiring eliminates need for individual home run cabling. From zone locations, modular connectorized power cables distribute power to any point where electrical power is required, terminating into workstation modules installed within user workspace, or directly to common-use receptacles located throughout the work space.
- C. Modular connectors shall be non-conductive and non-corrosive, and shall accommodate up to 10 conductors employing the following safety features:
1. Mating connectors shall be a positive locking type that prevents inadvertent unplugging, and be keyed by physical or mechanical means to maintain correct polarity, preventing the interconnection of dissimilar voltages.
 2. The connector design shall be such that no part or portion of the mating assembly can be inserted into the connector, and make contact with any current-carrying part of the system.
 3. Grounding conductor contact on each modular assembly shall be designed and manufactured to provide for First Make/Last Break (FM/LB) feature, such that grounding connection is made before contact being made with current-carrying conductors when connectors are mated. Grounding conductor shall break its connection only after current-carrying conductors have broken their connections when connectors are disengaged.
 4. The connector housing shall totally enclose the pin connector and the cable's conductors as they enter into the rear of the 10-pin connector.
 5. Contacts of 10-pin connector shall conform to MIL-STD-202, 204 Cond. A and 213 Cond. A. to ensure durability, and UL 486A for crimp retention force.
 6. Plastic housings encase contacts within a modular connector.
 - a. UL flammability rating of 94V0.
 - b. Genderless and keyed to prevent possible mismatching of dissimilar voltages.

- c. Color coded to match industry-standard wiring colors (for example, green, black, red, blue, white, and grey) to aid in system installation and troubleshooting.

1.5 SUBMITTALS

- A. Comply with Section 01 33 00 - Submittal Procedures.
- B. Product Data: Submit manufacturer's product data, including installation instructions, catalog cuts, and samples if requested, of each component used.
- C. Project Record Documents: Submit project record documents, including as-built drawings, wiring diagrams, power distribution module layout and feeder cable configuration. The manufacturer shall furnish an engineered layout for the Architect's approval and for the Electrical Contractor's use showing all components and circuitry.
- D. Warranty: Submit manufacturer's standard warranty.

1.6 QUALITY ASSURANCE

- A. Modular Wiring System:
 - 1. Electrical Distribution System: UL Listed as Manufactured Wiring System, compliant with UL 183 and 2043, approved for use in environmental air handling spaces in accordance with National Electrical Code, Article 300-22(c)(1).
 - 2. Workstation Termination Modules: UL Listed as Manufactured Wiring System, compliant with UL 183 standard for safety.
 - 3. Compliant with International Mechanical Code, Section 602.2.1.4.
 - 4. Compliant with grounding and shielding requirements of TIA/EIA 568-A and 569-A and National Electrical Code, Article 800-52(a).
 - 5. UL listing shall allow for 3-phase, 120/208 volts and/or 1-phase, 120/240 volts, 50 Hz or 60 Hz power distribution, 20 amps.
 - 6. Manufactured Wiring System: Compliant with National Electrical Code, Article 604.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver materials to site in manufacturer's original, unopened, protective containers and packaging, with labels clearly identifying product name and manufacturer.
- B. Storage: Store materials in secure, clean, dry area indoors in accordance with manufacturer's instructions.
- C. Handling: Protect materials and finish from damage and moisture during handling and installation.

1.8 WARRANTY

- A. Modular Wiring System: Warranted to be free from defects in material and workmanship for period of 5 years from system shipment.

PART 2 - PRODUCTS**2.1 MANUFACTURER**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Communications Integrators, Inc.
2. American Cable
3. Hubbell
4. Spider Agile Technology
5. Wiremold

2.2 MODULAR WIRING SYSTEM - DISTRIBUTION

A. Standard Capacity Power Distribution Modules (PDM):

1. Model:

- a. Ultra Low Profile For use beneath 2 ½" minimum FFH

2. Ports:

- a. Ultra Low Profile: Up to 4 output ports, 1 input port

3. Circuits of General Purpose Power Distribution: 6 maximum.

4. Connect to Circuit Breaker: Open power cables.

5. Connect to Master Power Distribution Module: Closed power cables.

6. Grounding Conductors:

- a. As required by National Electrical Code via open or closed power cables.
- b. Insulated green with yellow stripe grounding conductor shall be furnished when isolated ground system is required.

7. Construction

- a. Material: Cold-rolled steel.

- b. Minimum Thickness: 18 gauge (0.048 inch, plus or minus 0.005 inch).

- c. Finish: G-90 galvanized sheet steel

8. Designate Preferred Labeling: Custom silk screened.

9. Mounting Brackets

10. Ten-Pin Quick-Connect Connectors: Secure using positive locking tabs.

11. Mechanical-Type Ground Stud: For equipment ground conductor.

12. Equipment Ground Conductor: Attach to ground stud and extend to each modular connector and connect to each ground pin position.

13. Connector Housing:

- a. Clearly label as an input port or output port.
- b. Dust Cover: Prevent ingress of dust and debris.

B. Conversion Modules (CM):

1. Description: Allow for interfacing of building permanent wiring to modular wiring system.
 2. Construction:
 - a. Material: Cold-rolled steel.
 - b. Minimum Thickness: 18 gauge (0.048 inch, plus or minus 0.005 inch).
 - c. Finish: G-90 galvanized.
 3. Size: Sized to attach to industry-standard 4-11/16-inch by 4-11/16-inch electrical junction box.
 4. Ten-Pin Connector:
 - a. Quantity: 1.
 - b. Wire into building permanent wiring.
 - c. Secure using positive locking tabs.
- C. Open Power Cables: Open PowerMate Home Run and Device Cables.
1. Modular
 - a. Description: Squarelock-constructed, super-flexible, steel conduit, carrying up to 10 conductors of No. 12 AWG and/or No. 10 AWG multi-strand copper wire, co-labeled as THHN and T90, 90-degree C, 600-volt insulation, compliant with National Electrical Code, Article 604.
 - b. Construction: Super-flex, Appliance Grade Flexible Metal Conduit having minimum bend radii of 1 ¼" for ½" Super-Flex FMC, 1 ½ " for 9/16" Super-Flex FMC and 1 ¾" for ¾ "Super-Flex FMC.
 - c. Ten-Pin Quick-Connect Modular Connector: Fitted to one end of cable for modular, quick-connect connection to PDM.
 - d. Open End of Cables: Fit with conduit fitting, suitable for connection to building power, with a minimum of 12 inches of each conductor pigtailed out of open end of cable.
 - e. Label Cables:
 - 1) Circuitry of each conductor.
 - 2) Date of testing.
 - 3) Length of cable in feet.
- D. Closed Power Cables: Closed PowerMate Jumper Cables.
1. Description: Squarelock-constructed, super-flexible, steel conduit, carrying up to 10 conductors of No. 12 AWG and/or No. 10 AWG multi-strand copper wire, co-labeled as THHN and T90, 90-degree C, 600-volt insulation, compliant with National Electrical Code, Article 604.
 2. Construction: Super-flex, Appliance Grade Flexible Metal Conduit having minimum bend radii of 1 ¼" for ½" Super-Flex FMC, 1 ½ " for 9/16" Super-Flex FMC and 1 ¾" for ¾ "Super-Flex FMC

2. Ten-Pin Quick-Connect Modular Connector: Fitted to both ends of cable for connection between PDM and workstation terminal device.

3. Label Cables:

- a. Circuitry of each conductor.
- b. Date of testing.
- c. Length of cable in feet.

E. Coupler Modules:

1. Description: When fitted with two 10-pin quick-connect connectors, shall provide means for 2 connectorized open or closed power cables to be joined together.

2. Construction:

- a. Material: Cold-rolled steel.
- b. Minimum Thickness: 18 gauge (0.048 inch, plus or minus 0.005 inch).
- c. Finish: Catalyzed urethane enamel.

3. Ten-Pin Quick-Connect Connectors: Secure using positive locking tabs.

4. Mechanical-Type Ground Stud: For equipment ground conductor.

5. Equipment Ground Conductor: Attach to ground stud and extend to both modular connectors and connect to their respective ground pin positions.

6. Cover: Indicate input and output at modular connectors.

7. Each Connector: Label to identify function.

F. T-Connect Module:

1. Description:

- a. Open power cable, Squarelock-constructed, flexible steel conduit, carrying up to 10 conductors of No. 12 AWG and/or No. 10 AWG multi-strand copper wire, co-labeled as THHN and T90, 90-degree C, 600-volt insulation. Super-flex, Appliance Grade Flexible Metal Conduit having minimum bend radii of 1 ¼" for ½" Super-Flex FMC, 1 ½ " for 9/16" Super-Flex FMC and 1 ¾" for ¾ "Super-Flex FMC. Five (5) foot length typical, fitted to sheet steel enclosure. Within the enclosure the power cable is wired to two (2) fixed-position 10-pin connectors. Open end of power cable feeds wall and/or column mounted receptacle(s), providing for modular daisy-chain type interface between wall and/or column mounted receptacles and underfloor modular power distribution.
- b. Systems Furniture Power Entry cable, 6 foot typical, fitted to sheet steel enclosure. Within the enclosure the power cable is wired to 2 fixed-position 10-pin connectors. Open end of Systems

Furniture Power Entry cable supplies electrical power to Systems Furniture receptacle(s), providing for modular daisy-chain type interface between Systems Furniture clusters and underfloor modular power distribution.

2. Grounding Conductors: As required by National Electrical Code via open power cables.
3. Construction:
 - a. Material: Cold-rolled steel.
 - b. Minimum Thickness: 18 gauge (0.048 inch, plus or minus 0.005 inch).
 - c. Finish: Galvanized or powder coat.
 - d. Makeshift junction boxes and the like will not be accepted.
4. Open Power Cable: Squarelock-constructed, super-flexible, steel conduit, carrying No. 12 AWG and/or No. 10 AWG multi-strand copper wire, THHN, 90-degree C, 600-volt insulation, having a minimum of 12 inches of each conductor pigtailed out of open end of the flexible steel conduit to facilitate connection to the wall mounted receptacle(s).
6. Ten-Pin Connectors: Secure to enclosure with positive locking tabs.
7. Mechanical-Type Ground Stud: For equipment ground conductor.
8. Equipment Ground Conductor: Attach to ground stud and extend to each quick-connector and open power cable.

G. 3-Way Splitter Module:

1. Description: a "One In-Two Out" power hub which provides a means for routing the branch circuits of a PowerMate Jumper Cable to two separate devices, having one input port and two output ports, both of which duplicate the Splitter Module's input.
2. Construction:
 - a. Material: Cold-rolled steel.
 - b. Minimum Thickness: 18 gauge (0.048 inch, plus or minus 0.005 inch).
 - c. Finish: Catalyzed urethane enamel.
3. Ten-Pin Quick-Connect Connectors: Secure using positive locking tabs.
4. Equipment Ground Conductor: Attach to ground stud and extend to both modular connectors and connect to their respective ground pin positions.
5. Cover: Indicate input and output ports at modular connectors.

2.3 MODULAR WIRING SYSTEM - WORKSTATION TERMINATION

A. Workstation Termination Modules: Raised Access Floor Box.

1. Description: Standard UL-listed and UL-labeled assemblies for recessed mounting flush with top of raised access floor panels for power, communication, and signal services.
2. High Capacity, Low Floor Height: Use in raised access floors with minimum of 2-1/2 inches finished floor height.
 - a. Receptacles: 2, 20-amp duplex receptacles.
 - b. Capacity: Maximum 6 circuits, 96 amps.
 - c. Connection: [2 x 10-pin connectors.] [Knockout for hard wired connection]
 - d. Wiring: [#12 AWG multi-strand copper] [#10 AWG multi-strand copper]
 - e. Voice and Data Termination Points: Separated and electromagnetically shielded from power. Accommodate most manufacturers' CAT 6 or enhanced CAT 5 jacks.
3. Structural Performance: Cover capable of supporting 1,000-lbf, (4,448 N) concentrated load.
4. Cover and Box: Hinged polycarbonate cover with openings for passage of device cables and cords when cover is closed. Including frame and steel box with provision for RJ45/RJ11 information management outlets and signal cables, and formed-steel plate enclosure for mounting electrical receptacles. The box and steel mounting plates shall be constructed of 0.058" minimum thickness galvanized steel.
5. Receptacles and Wiring: Equip each modular access floor box with power receptacles.
 - a. Receptacle Type: Commercial-grade, 2-pole, 3-wire grounding, 20 A, 125 V, NEMA 5-20R, unless otherwise indicated.
 - b. Number of Receptacles for Access Floor Box: 2.
 - c. Wiring Method for Recessed Modular Connector: 1 power-in connector, 1 power-out connector, built into modular access floor box housing, of type to fit power-in and power-out connectors of branch-circuit cables supplied with building electrical system as specified in Modular Wiring System - Distribution of this section.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive modular wiring system. Notify Architect of conditions that would adversely affect installation or subsequent use. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install modular wiring system in accordance with manufacturer's

instructions, system design drawings, National Electrical Code, and local municipal codes as required.

- B. Coordinate installation of modular wiring system with other work in progress.
- C. The system manufacturer shall provide job-site instructions to the electrical contractor for review, installation, methods of materials shipping, and identification of system components.
- D. The Electrical Contractor shall furnish and install junction boxes where transitions are made from the conventional hard wiring mode to the manufactured wiring system. All cable assemblies shall be installed in accordance with the installation drawings. Provide cable supports at intervals not to exceed the specifications of NEC. Manufacturer shall provide dust caps on all unused connector faces.
- E. Power distribution modules shall be located in readily accessible locations below the raised floor or above the ceiling. Locations shown on manufacturer's layout drawings shall be considered schematic. The contractor shall consider accessibility as a prime factor when locating modules.
- F. The contractor shall identify any changes to the manufactured wiring system installation drawings made during the installation and furnish these to the manufacturer to update the as-built drawings.

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SECTION 26 27 26**WIRING DEVICES****PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation and connection of wiring devices.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlets boxes.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, construction materials, grade and termination information.
- C. Manuals: Two weeks prior to final inspection, deliver four copies of the following to the COTR: Technical data sheets and information for ordering replacement units.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR: Certification by the Contractor that the devices comply with the drawings and specifications, and have been properly installed, aligned, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent

referenced. Publications are referenced in the text by basic designation only.

- B. National Fire Protection Association (NFPA):
 - 70.....National Electrical Code (NEC)
- C. National Electrical Manufacturers Association (NEMA):
 - WD 1.....General Color Requirements for Wiring Devices
 - WD 6Wiring Devices - Dimensional Requirements
- D. Underwriter's Laboratories, Inc. (UL):
 - 5.....Surface Metal Raceways and Fittings
 - 20.....General-Use Snap Switches
 - 231.....Power Outlets
 - 467.....Grounding and Bonding Equipment
 - 498.....Attachment Plugs and Receptacles
 - 943.....Ground-Fault Circuit-Interrupters

PART 2 - PRODUCTS

2.1 RECEPTACLES

- A. General: All receptacles shall be listed by Underwriters Laboratories, Inc., and conform to NEMA WD 6.
 - 1. Mounting straps shall be plated steel, with break-off plaster ears and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.
 - 2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four min.) and side wiring from four captively held binding screws.
 - 3. Ground Fault Interrupter Duplex Receptacles: Shall be an integral unit, hospital-grade, suitable for mounting in a standard outlet box.
 - a. Ground fault interrupter shall be consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of five milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (+ or - 1 milliamp) on the load side of the device. Device shall have a minimum nominal tripping time of 1/30th of a second.
 - b. Ground Fault Interrupter Duplex Receptacles (not hospital-grade) shall be the same as ground fault interrupter hospital-grade receptacles except for the "hospital-grade" listing.
 - 4. Safety Type Duplex Receptacles:
 - a. Bodies shall be gray in color.

- 1) Shall permit current to flow only while a standard plug is in the proper position in the receptacle.
 - 2) Screws exposed while the wall plates are in place shall be the tamperproof type.
5. Duplex Receptacles (not hospital grade): Shall be the same as hospital grade duplex receptacles except for the "hospital grade" listing and as follows.
- a. Bodies shall be brown phenolic compound supported by a plated steel mounting strap having plaster ears.
- C. Receptacles; 20, 30 and 50 ampere, 250 volts: Shall be complete with appropriate cord grip plug. Devices shall meet UL 231.
- D. Weatherproof Receptacles: Shall consist of a duplex receptacle, mounted in box with a gasketed, weatherproof, cast metal cover plate and cap over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.
- E. TVSS Receptacles. Shall comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.
1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
 2. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

2.2 TOGGLE SWITCHES

- A. Toggle Switches: Shall be totally enclosed tumbler type with bodies of phenolic compound. Toggle handles shall be ivory in color unless otherwise specified. The rocker type switch is not acceptable and will not be approved.
1. Switches installed in hazardous areas shall be explosion proof type in accordance with the NEC and as shown on the drawings.
 2. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self grounding mounting strap with break-off plaster ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.

3. Ratings:

- a. 120 volt circuits: 20 amperes at 120-277 volts AC.
- b. 277 volt circuits: 20 amperes at 120-277 volts AC.

2.3 MANUAL DIMMING CONTROL

- A. slide dimmer with on/off control, single-pole or three-way as shown on plans. Faceplates shall be ivory in color unless otherwise specified.
- B. Manual dimming controls shall be fully compatible with electronic dimming ballasts and approved by the ballast manufacturer, shall operate over full specified dimming range, and shall not degrade the performance or rated life of the electronic dimming ballast and lamp.

2.4 WALL PLATES

- A. Wall plates for switches and receptacles shall be type 302 stainless steel. Oversize plates are not acceptable.
- B. Standard NEMA design, so that products of different manufacturers will be interchangeable. Dimensions for openings in wall plates shall be accordance with NEMA WD 6.
- C. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.
- D. In psychiatric areas, wall plates shall be 302 stainless steel, have tamperproof screws and beveled edges.
- E. Wall plates for data, telephone or other communication outlets shall be as specified in the associated specification.
- F. Duplex Receptacles on Emergency Circuit:
 - 1. Bodies shall be red in color. Wall plates shall be red with the word "EMERGENCY" engraved in 6 mm, (1/4 inch) white letters.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC and as shown as on the drawings.
- B. Ground terminal of each receptacle shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the green equipment grounding conductor.
- C. Outlet boxes for light and dimmer switches shall be mounted on the strike side of doors.
- D. Provide barriers in multigang outlet boxes to separate systems of different voltages, Normal Power and Emergency Power systems, and in compliance with the NEC.
- E. Coordinate with other work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other work. Coordinate the electrical work with the work

of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with laboratory equipment.

- F. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and equipment, the Contractor shall coordinate exact field location of the above items with other trades. In addition, check for exact direction of door swings so that local switches are properly located on the strike side.
- G. Install wall switches 48 inches [1200mm] above floor, OFF position down.
- H. Install wall dimmers 48 inches [1200mm] above floor; derate ganged dimmers as instructed by manufacturer; do not use common neutral.
- I. Install convenience receptacles 18 inches [450mm] above floor, and 6 inches [152mm] above counter backsplash or workbenches. Install specific-use receptacles at heights shown on the drawings.
- J. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.
- K. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.
- L. Test GFCI devices for tripping values specified in UL 1436 and UL 943.

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SECTION 26 29 11**MOTOR STARTERS****PART 1 - GENERAL****1.1 DESCRIPTION**

All motor starters and variable speed motor controllers, including installation and connection (whether furnished with the equipment specified in other Divisions or otherwise), shall meet these specifications.

1.2 RELATED WORK

- A. Other sections which specify motor driven equipment, except elevator motor controllers.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one Section of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL: For metering devices integral to the starters.
- E. Section 26 24 19, MOTOR-CONTROL CENTERS and Section 26 24 21, MOTOR-CONTROL PANELBOARDS: For multiple motor control assemblies, which include motor starters.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:

- A. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, weights, mounting details, materials, running over current protection, size of enclosure, over current protection, wiring diagrams, starting characteristics, interlocking and accessories.
- B. Manuals:
 - 1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data

- sheets, wiring diagrams and information for ordering replacement parts.
- a. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance and operation.
 - b. Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.
 - c. Elementary schematic diagrams shall be provided for clarity of operation.
2. Two weeks prior to the project final inspection, submit four copies of the final updated maintenance and operating manual to the COTR.
- C. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certifications to the COTR:
1. Certification that the equipment has been properly installed, adjusted, and tested.
 2. Certification by the manufacturer that medium voltage motor controller(s) conforms to the requirements of the drawings and specifications. This certification must be furnished to the COTR prior to shipping the controller(s) to the job site.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
- 519.....Recommended Practices and Requirements for
Harmonic Control in Electrical Power Systems
 - C37.90.1.....Standard Surge Withstand Capability (SWC) Tests
for Protective Relays and Relay Systems
- C. National Electrical Manufacturers Association (NEMA):
- ICS 1.....Industrial Control and Systems General
Requirements
 - ICS 1.1.....Safety Guidelines for the Application,
Installation and Maintenance of Solid State
Control
 - ICS 2.....Industrial Control and Systems, Controllers,
Contactors and Overload Relays Rated 600 Volts
DC
 - ICS 6.....Industrial Control and Systems Enclosures
 - ICS 7.....Industrial Control and Systems Adjustable-Speed
Drives

ICS 7.1.....Safety Standards for Construction and Guide for
Selection, Installation and Operation of
Adjustable-Speed Drive Systems

D. National Fire Protection Association (NFPA):

70.....National Electrical Code (NEC)

E. Underwriters Laboratories Inc. (UL):

508.....Industrial Control Equipment

PART 2 - PRODUCTS

2.1 MOTOR STARTERS, GENERAL

- A. Shall be in accordance with the requirements of the IEEE, NEC, NEMA (ICS 1, ICS 1.1, ICS 2, ICS 6, ICS 7 and ICS 7.1) and UL.
- B. Shall have the following features:
 - 1. Separately enclosed unless part of another assembly.
 - 2. Circuit breakers and safety switches within the motor controller enclosures shall have external operating handles with lock-open padlocking provisions and shall indicate the ON and OFF positions.
 - 3. Motor control circuits:
 - a. Shall operate at not more than 120 volts.
 - b. Shall be grounded except as follows:
 - 1) Where isolated control circuits are shown.
 - 2) Where manufacturers of equipment assemblies recommend that the control circuits be isolated.
 - c. Incorporate a separate, heavy duty, control transformer within each motor controller enclosure to provide the control voltage for each motor operating over 120 volts.
 - d. Incorporate over current protection for both primary and secondary windings of the control power transformers in accordance with the NEC.
 - 4. Overload current protective devices:
 - a. Overload relay (solid state type.
 - b. One for each pole.
 - c. Manual reset on the door of each motor controller enclosure.
 - d. Correctly sized for the associated motor's rated full load current.
 - e. Check every motor controller after installation and verify that correct sizes of protective devices have been installed.
 - f. Deliver four copies of a summarized list to the COTR, which indicates and adequately identifies every motor controller installed. Include the catalog numbers for the correct sizes of protective devices for the motor controllers.

5. Hand-Off-Automatic (H-O-A) switch is required unless specifically stated on the drawings as not required for a particular starter. H-O-A switch is not required for manual motor starters.
6. Incorporate into each control circuit a 120-volt, solid state time delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection.
7. Unless noted otherwise, equip with not less than two normally open and two normally closed auxiliary contacts. Provide green run pilot lights and H-O-A control devices as indicated, operable at front of enclosure without opening enclosure. Push buttons, selector switches, pilot lights, etc., shall be interchangeable.
8. Enclosures:
 - a. Shall be the NEMA types shown on the drawings for the motor controllers and shall be the NEMA types which are the most suitable for the environmental conditions where the motor controllers are being installed.
 - b. Doors mechanically interlocked to prevent opening unless the breaker or switch within the enclosure is open. Provision for padlock must be provided.
 - c. Enclosures shall be primed and finish coated at the factory with the manufacturer's prime coat and standard finish.
- C. Motor controllers incorporated with equipment assemblies shall also be designed for the specific requirements of the assemblies.
- D. For motor controllers being installed in existing motor control centers or panelboards, coordinate with the existing centers or panelboards.
- E. Additional requirements for specific motor controllers, as indicated in other sections, shall also apply.
- F. Provide a disconnecting means or safety switch near and within sight of each motor. Provide all wiring and conduit required to facilitate a complete installation.

2.2 MANUAL MOTOR STARTERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Manual motor starters.
 1. Starters shall be general-purpose Class A, manually operated type with full voltage controller for induction motors, rated in horsepower.
 2. Units shall include overload and low voltage protection, red pilot light, NO auxiliary contact and toggle operator.
- C. Fractional horsepower manual motor starters.

1. Starters shall be general-purpose Class A, manually operated with full voltage controller for fractional horsepower induction motors.
2. Units shall include thermal overload protection, red pilot light and toggle operator.

D. Motor starting switches.

1. Switches shall be general-purpose Class A, manually operated type with full voltage controller for fractional horsepower induction motors.
2. Units shall include thermal overload protection, red pilot light // low voltage protection NO auxiliary contact and toggle operator.

2.3 MAGNETIC MOTOR STARTERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Starters shall be general-purpose, Class A magnetic controllers for induction motors rated in horsepower. Minimum size 0.
- C. Where combination motor starters are used, combine starter with protective or disconnect device in a common enclosure.
- D. Provide phase loss protection for each starter, with contacts to de-energize the starter upon loss of any phase.
- E. Unless otherwise indicated, provide full voltage non-reversing across-the-line mechanisms for motors less than 75 HP, closed by coil action and opened by gravity. For motors 75 HP and larger, provide reduced voltage starters. Equip starters with 120V AC coils and individual control transformer unless otherwise noted. Locate "reset" button to be accessible without opening the enclosure.

2.4 REDUCED VOLTAGE MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above.
- B. Shall be installed as shown for motors on the contract drawings.
- C. Shall have closed circuit transition for the types which can incorporate such transition.
- D. Shall limit inrush currents to not more than 70 percent of the locked rotor currents.
- E. Provide phase loss protection for each starter, with contacts to de-energize the starter upon loss of any phase.

2.5 VARIABLE SPEED MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above.
- B. Shall be solid state, micro processor-based with adjustable frequency and voltage, three phase output capable of driving standard NEMA B design, three phase alternating current induction motors at full rated speed. The drives shall utilize a full wave bridge design incorporating diode rectifier circuitry with pulse width modulation (PWM). Other

control techniques are not acceptable. Silicon controlled rectifiers (SCR) shall not be used in the rectifying circuitry. The drives shall be designed to be used on variable torque loads and shall be capable of providing sufficient torque to allow the motor to break away from rest upon first application of power.

- C. Unit shall be capable of operating within voltage parameters of plus 10 to minus 10 percent of line voltage, and be suitably rated for the full load amps of the maximum watts (HP) within its class.

D. Operating and Design Conditions:

Elevation: 1250 feet AMSL

Temperatures: Maximum +90°F Minimum -10°F

Relative Humidity: 95%

Drive Location: Air conditioned Building

E. Controllers shall have the following features:

1. Isolated power for control circuits.
2. Manually re-settable motor overload protection for each phase.
3. Adjustable current limiting circuitry to provide soft motor starting. Maximum starting current shall not exceed 200 percent of motor full load current.
4. Independent acceleration and deceleration time adjustment, manually adjustable from 2 to 30 seconds. (Set timers to the equipment manufacturer's recommended time in the above range.)
5. Provide 4 to 20 ma current follower circuitry for interface with mechanical sensor devices.
6. Automatic frequency adjustment from 20 Hz to 60 Hz.
7. Provide circuitry to initiate an orderly shutdown when any of the conditions listed below occur. The controller shall not be damaged by any of these electrical disturbances and shall automatically restart when the conditions are corrected. The drive shall be able to restart into a rotating motor operating in either the forward or reverse direction and matching that frequency.
 - a. Incorrect phase sequence.
 - b. Single phasing.
 - c. Over voltage in excess of 10 percent.
 - d. Under voltage in excess of 10 percent.
 - e. Running over current above 110 percent (shall not automatically reset for this condition.)
 - f. Instantaneous overcurrent above 150 percent (shall not automatically reset for this condition).
 - g. Surge voltage in excess of 1000 volts.

- h. Short duration power outages of 12 cycles or less (i.e., distribution line switching, generator testing, and automatic transfer switch operations.)
- 8. Provide automatic shutdown on receipt of a power transfer warning signal from an automatic transfer switch. Controller shall automatically restart motor after the power transfer.
- 9. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- 10. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- 11. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- F. Minimum efficiency shall be 95 percent at 100 percent speed and 85percent at 50 percent speed.
- G. The displacement power factor of the controller shall not be less than 95 percent under any speed or load condition.
- H. Controllers shall include a door interlocked fused safety disconnect switch or door interlocked circuit breaker switch which will disconnect all input power.
- I. Include a by-pass starter with circuitry to protect and isolate the variable speed controller. When the variable speed controller is in the by-pass mode, the solid-state components shall be isolated from the power supply on both the line and motor side. Motor overload protection shall be active in by-pass operation.
- J. The following accessories are to be door mounted:
 - 1. AC Power on light.
 - 2. Ammeter (RMS motor current).
 - 3. HAND-OFF-AUTOMATIC switch.
 - 4. Manual speed control in HAND mode.
 - 5. System protection lights indicating that the system has shutdown and will not automatically restart.
 - 6. System protection light indicating that the system has shutdown but will restart when conditions return to normal.
 - 7. Manual variable speed controller by-pass switch.
 - 8. Diagnostic shutdown indicator lights for each shutdown condition.

9. Provide two N.O. and two N.C. dry contacts rated 120 volts, 10 amperes, 60 HZ for remote indication of the following:
 - a. System shutdown with auto restart.
 - b. System shutdown without auto restart.
 - c. System running.
10. Incorporate into each control circuit a 120-volt, time delay relay (ON delay), adjustable from 0.3-10 minutes, with transient protection. Provide transformer/s for the control circuit/s.
11. Controller shall not add any current or voltage transients to the input AC power distribution system nor shall transients from other devices on the AC power distribution system affect the controller. Controllers shall be protected to comply with IEEE C37.90.1 and UL-508. Line noise and harmonic voltage distortion shall not exceed the values allowed by IEEE 519. Include Harmonic filter within the enclosure of the VFD.
- K. Building automation system interface (BAS): Factory-installed hardware and software to enable the BAS to monitor, control, and display controller status and alarms.
- L. Network Communications Ports: Ethernet and RS-422/485.
- M. Embedded BAS Protocols for Network Communications: as specified in Division 22. protocols accessible via the communications ports.

2.7 MOTOR CONTROL STATIONS

- A. Shall have the following features:
 1. Designed for suitably fulfilling the specific control functions for which each station is being installed.
 2. Coordinate the use of momentary contacts and maintained contacts with the complete motor control systems to insure safety for people and equipment.
 3. Each station shall have two pilot lights behind red and green jewels and a circuit to its motor controller. Connect the lamps so they will be energized as follows:
 - a. Red while the motor is running.
 - b. Green while the motor is stopped.
 4. Where two or more stations are mounted adjacent to each other, install a common wall plate, except where the designs of the stations make such common plates impracticable.
 5. Identify each station with a permanently attached individual nameplate, of laminated black phenolic resin with a white core and engraved lettering not less than 6 mm (1/4-inch) high. Identify the

motor by its number or other designation and indicate the function fulfilled by the motor.

B. Components of Motor Control Circuits:

1. Shall also be designed and arranged so that accidental faulting or grounding of the control conductors will not be able to start the motors.
2. Use of locking type STOP pushbuttons or switches, which cause motors to restart automatically when the pushbuttons or switches are released, will not be permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor control equipment in accordance with manufacturer's recommendations, the NEC, NEMA and as shown on the drawings.
- B. Furnish and install heater elements in motor starters and to match the installed motor characteristics. Submit a list of all motors listing motor nameplate rating and heater element installed.
- C. Motor Data: Provide neatly-typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating and heater element installed.
- D. Connect hand-off auto selector switches so that automatic control only is by-passed in "manual" position and any safety controls are not by-passed.
- E. Install manual motor starters in flush enclosures in finished areas.
- F. Examine control diagrams indicated before ordering motor controllers. Should conflicting data exist in specifications, drawings and diagrams, request corrected data prior to placing orders.

3.2 ADJUSTING

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
- C. Adjust trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust at six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify COTR before increasing settings.

- D. Set the taps on reduced-voltage autotransformer controllers at 80 percent.
- E. In reduced-voltage solid-state controllers, set field-adjustable switches and program microprocessors for required start and stop sequences.

3.3 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
 - 1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Inspect contactors.
 - d. Clean motor starters and variable speed motor controllers.
 - e. Verify overload element ratings are correct for their applications.
 - f. If motor-running protection is provided by fuses, verify correct fuse rating.
 - g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - 2. Variable speed motor controllers:
 - a. Final programming and connections to variable speed motor controllers shall be by a factory-trained technician. Set all programmable functions of the variable speed motor controllers to meet the requirements and conditions of use.
 - b. Test all control and safety features of the variable frequency drive.

3.4 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the motor starters and variable speed motor controllers are in good operating condition and properly performing the intended functions.

3.5 SPARE PARTS

Two weeks prior to the final inspection, provide one complete set of spare fuses (including heater elements) for each starter/controller installed on this project.

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SECTION 26 29 21
DISCONNECT SWITCHES**PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation and connection of low voltage disconnect switches.

1.2 RELATED WORK

- A. General electrical requirements and items that is common to more than one section of Division 26: Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Conduits for cables and wiring: Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- C. Cables and wiring: Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW.
- D. Motor rated toggle switches: Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- E. Requirements for personnel safety and to provide a low impedance path for possible ground faults: Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1.3 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Include sufficient information, clearly presented to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, enclosure types, fuse type and class.
 - 3. Show the specific switch and fuse proposed for each specific piece of equipment or circuit.
- C. Manuals:
 - 1. Provide complete maintenance and operating manuals for disconnect switches, including technical data sheets, wiring diagrams, and information for ordering replacement parts. Deliver four copies to the COTR two weeks prior to final inspection.
 - 2. Identify terminals on wiring diagrams to facilitate maintenance and operation.
 - 3. Wiring diagrams shall indicate internal wiring and any interlocking.

- D. Certification: Two weeks prior to final inspection, deliver to the COTR four copies of the certification that the equipment has been properly installed, adjusted, and tested.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
KS 1-01.....Enclosed and Miscellaneous Distribution
Equipment Switches (600 Volts Maximum)
- C. National Fire Protection Association (NFPA):
70-05.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
98-98.....Enclosed and Dead-Front Switches
198C-89.....High-Interrupting-Capacity Fuses, Current
Limiting Types
198E-94.....Class R Fuses
977-99.....Fused Power-Circuit Devices

PART 2 - PRODUCTS

2.1 LOW VOLTAGE FUSIBLE SWITCHES RATED 600 AMPERES AND LESS

- A. Shall be quick-make, quick-break type in accordance with UL 98, NEMA KS 1 and NEC.
- B. Shall have a minimum duty rating, NEMA classification General Duty (GD) for 240 volts and NEMA classification Heavy Duty (HD) for 277/480 volts.
- C. Shall be horsepower rated.
- D. Shall have the following features:
1. Switch mechanism shall be the quick-make, quick-break type.
 2. Copper blades, visible in the OFF position.
 3. An arc chute for each pole.
 4. External operating handle shall indicate ON and OFF position and shall have lock-open padlocking provisions.
 5. Mechanical interlock shall permit opening of the door only when the switch is in the OFF position, defeatable by a special tool to permit inspection.
 6. Fuse holders for the sizes and types of fuses specified.
 7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
 8. Ground Lugs: One for each ground conductor.
 9. Enclosures:

- a. Shall be the NEMA types shown on the drawings for the switches.
- b. Where the types of switch enclosures are not shown, they shall be the NEMA types which are most suitable for the environmental conditions where the switches are being installed. Unless otherwise indicated on the plans, all outdoor switches shall be NEMA 3R.
- c. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel (for the type of enclosure required).

2.2 LOW VOLTAGE UNFUSED SWITCHES RATED 600 AMPERES AND LESS

Shall be the same as Low Voltage Fusible Switches Rated 600 Amperes and Less, but no fuses.

2.3 LOW VOLTAGE FUSIBLE SWITCHES RATED OVER 600 AMPERES TO 1200 AMPERES

Shall be the same as Low Voltage Fusible Switches Rated 600 Amperes and Less, except for the minimum duty rating which shall be NEMA classification Heavy Duty (HD). These switches shall also be horsepower rated.

2.4 MOTOR RATED TOGGLE SWITCHES

Refer to Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS for motor rated toggle switches.

2.5 IDENTIFICATION SIGNS

- A. Install nameplate identification signs on each disconnect switch to identify the equipment controlled.
- B. Nameplates shall be laminated black phenolic resin with a white core, with engraved lettering, a minimum of 6 mm (1/4-inch) high. Secure nameplates with screws.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install disconnect switches in accordance with the NEC and as shown on the drawings.
- B. Fusible disconnect switches shall be furnished complete with fuses.

3.2 SPARE PARTS

Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fusible disconnect switch installed on the project. Deliver the spare fuses to the COTR.

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SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL**1.1 DESCRIPTION**

This section specifies the furnishing, complete installation, and connection of automatic transfer switches.

1.2 RELATED WORK

- A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic requirements for non-structural equipment.
- B. Section 14 21 00, ELECTRIC TRACTION ELEVATORS: Requirements for elevator operation.
- C. Section 14 24 00, HYDRAULIC ELEVATORS: Requirements for elevator operation.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that is common to more than one section of Division 26.
- E. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Requirements for coordinated electrical system.
- F. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and Wiring.
- G. Section 26 32 13, ENGINE GENERATORS: Requirements for emergency power generation.
- H. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personal safety and to provide a low impedance path for possible ground fault currents.

1.3 QUALITY ASSURANCE

- A. Factory authorized representative shall maintain a service center capable of providing emergency maintenance and repair services at the project site within 4 hour maximum response time.
- B. Automatic transfer switch, bypass/isolation switch and annunciation control panels shall be products of same manufacturer.
- C. Comply with OSHA - 29 CFR 1910.7 for the qualifications of the testing agency.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.

2. Include electrical ratings (including withstand), dimensions, weights, mounting details, conduit entry provisions front view, side view, equipment and device arrangement, elementary and interconnection wiring diagrams, and accessories.
3. Complete nameplate data, including manufacturer's name and catalog number.
4. A copy of the markings that are to appear on the transfer switches when installed.

C. Manuals:

1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating and maintenance manuals including technical data sheets, wiring diagrams and information, such as telephone number, fax number and web sites, for ordering replacement parts.
2. Two weeks prior to final inspection, submit four copies of a final updated maintenance and operating manual to the COTR.
 - a. Include complete "As installed" diagrams, which indicate all items of equipment and their interconnecting wiring.
 - b. Include complete diagrams of the internal wiring for each of the items of equipment, including "As installed" revisions of the diagrams.
 - c. The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation and testing.

D. Certifications:

1. Submit, simultaneously with the shop drawings, a certified test report from a recognized independent testing laboratory that a representative sample has passed UL 1008 (Prototype testing).
2. Additionally when transfer switches are used with power air circuit breakers having short-time trip elements without instantaneous trip elements provide a certified test report showing that the sample has passed the additional withstand requirements of this specification. Method of test shall be in accordance with UL 1008. Main contact separation as measured by an oscillograph voltage trace across the contacts will not be allowed during this test. Welding or burning of contacts is unacceptable.
3. Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - a. Certification that no design changes have been made to the switch or its components since last certified by UL or as tested by an independent laboratory.

- b. Certification by the manufacturer that the equipment conforms to the requirements of the drawings and specifications.
- c. Certification by the Contractor that the equipment has been properly installed, adjusted, and tested.
- d. A certified test report from an independent laboratory that a representative sample has passed the ANSI surges withstand test for transfer switches which incorporate solid-state components.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only:
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - 446-95.....Recommended Practice for Design and Maintenance of Emergency and Standby Power Systems
 - C37.90.1-02.....IEEE Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
- C. National Electrical Manufacturers Association (NEMA):
 - 250-03.....Enclosure for Electrical Equipment (1000 Volts Maximum).
 - ICS 6-01.....Industrial Control and Systems Enclosures
 - IC3 4.....Industrial Control and Systems: Terminal Blocks
 - MG 1-03.....Motors and Generators, Revision 1
- D. National Fire Protection Association (NFPA):
 - 70-05.....National Electrical Code (NEC)
 - 99-05.....Health Care Facilities
 - 110.....Emergency and Standby Power Systems
- E. Underwriters Laboratories, Inc. (UL):
 - 50-03.....Enclosures for Electrical Equipment
 - 508-02.....Industrial Control Equipment
 - 891-03.....Dead-Front Switchboards
 - 1008-03.....Transfer Switch Equipment

PART 2 - PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

- A. General:
 - 1. Comply with UL, NEMA, NEC, ANSI and NFPA.
 - 2. Automatic transfer switches are to be electrically operated, mechanically held open contact type, without integral overcurrent protection. Transfer switches utilizing automatic or non-automatic molded case circuit breakers as switching mechanisms are not acceptable.

3. The unit shall be completely factory-assembled and wired so that only external circuit connections are required in the field. The unit shall include, but not be limited to, operating mechanism, main contacts, auxiliary contacts, timers, pilot lights, switches, and auxiliary sensing devices.
4. Each transfer switch shall be equipped with bypass/ isolation switch. The switch shall be part of the transfer switch.

B. Ratings, Markings and Tests:

1. Ratings:

- a. Phase, voltage, ampere rating, number of poles, withstand rating shall be as shown on the drawings. The ampere rating shall be for 100 percent continuous load current.
- b. Transfer switches are to be rated for total system transfer on emergency systems.
- c. Ratings shall be with non-welding of contacts during the performance of withstand and closing tests.
- d. Maximum automatic transfer switch rating: 800 amperes

2. Markings:

- a. Markings shall be in accordance with UL 1008.
- b. Markings for the additional withstand test hereinafter specified shall be included in the nameplate data.

3. Tests:

- a. Transfer switches shall be tested in accordance with UL 1008. The contacts of the transfer switch shall not weld during the performance of withstand and closing tests when used with the upstream overcurrent device.
- b. Where used with molded case circuit breakers or power air circuit breakers with long-time and instantaneous trip, transfer switch withstand and closing rating shall equal or exceed the available short circuit current shown on the drawings, but shall not be less than the following:

Switch Rating (Amperes)	Withstanding Amperes (RMS Symmetrical)	Circuit Power Factor
Up to 100	22,000	Per UL
101 to 260	35,000	Per UL
261 to 400	42,000	Per UL
410 to 600	50,000	Per UL
601 to 1200	65,000	Per UL
1201 to 4000	85,000	Per UL

4. Additional Withstand Test:

- a. See paragraph 1.4.D.1 for certification of "Withstand Test."
- b. Where used with power air circuit breakers with long-time and short-time trips without instantaneous trip, transfer switch withstand rating shall be based on the available short circuit current (RMS symmetrical) for a duration of ten cycles.

5. Surge Withstand Test:

- a. Transfer switches utilizing solid-state devices in sensing, relaying, operating, or communication equipment or circuits shall comply with ANSI C37.90.1.

C. Housing:

1. Enclose transfer switches in steel cabinets in accordance with UL 508, or in a switchboard assembly in accordance with UL 891, as shown on the drawings. NEMA ICS 6 Type as indicated on the drawings.
2. Doors: Shall have three-point latching mechanism.
3. Padlocking Provisions: Provide chain for attaching a padlock. Attach chain to the cabinet by welding or riveting.
4. Finish: Cabinets shall be given a phosphate treatment, painted with rust inhibiting primer, and finish painted with the manufacturer's standard enamel or lacquer finish.

2.2 FEATURES

A. Transfer switches shall include the following features:

1. Operating Mechanism:

- a. Actuated by an electrical operator.
- b. Electrically and mechanically interlocked so that the main contact cannot be closed simultaneously in both normal and emergency position.
- c. Normal and emergency main contacts shall be mechanically locked in position by the operating linkage upon completion of transfer. Release of the locking mechanism shall be possible only by normal operating action.
- d. Shall include a neutral position.
- e. Contact transfer time shall not exceed six cycles.
- f. Do not use as a current carrying part. Components and mechanical interlocks shall be insulated or grounded.

2. Contacts:

- a. For switches 400 amperes and larger, protect main contacts by separate arcing contacts and magnetic blowouts for each pole. Arc quenching provisions equivalent to magnetic blowouts will be considered acceptable.

- b. Current carrying capacity of arcing contacts shall not be used in the determination of the transfer switch rating, and shall be separate from the main contacts.
- c. Main and arcing contacts shall be visible for inspection with cabinet door open and barrier covers removed.
- 3. Manual Operator:
 - a. Capable of operation in either direction under no load.
 - b. Capable of operation by one person.
 - c. Provide a warning sign to caution against operation when energized.
- 4. Replaceable Parts:
 - a. Include the main and arcing contact individually or as units, relays, and control devices.
 - b. Switch contacts and accessories are to be replaceable from the front without removing the switch from the cabinet and without removing main conductors.
- 5. Sensing Relays:
 - a. Provide voltage-sensing relays in each phase of the normal power supply.
 - b. Provide adjustable voltage and frequency sensing relays in one phase of the auxiliary power supply.
- 6. Controls:
 - a. Control module shall provide indication of switch status - emergency, normal, and be equipped with alarm diagnostic circuitry.
 - b. Control module shall control operation of the transfer switch. The sensing and the logic shall be controlled by a microprocessor equipped with digital communication and battery backup. The control shall comply with IEEE 472.

2.3 ACCESSORIES

- A. Transfer switches shall include the following accessories:
 - 1. Indicating Lights of different colors:
 - a. Green Signal light for normal source position.
 - b. Red Signal light for emergency source position.
 - 2. Laminated black phenolic nameplates with white letters to indicate transfer switch position.
- B. Manual Test Switch for simulating normal source failure.
- C. Engine starting contacts.
- D. Time delay relay to accomplish the function as specified.
- E. Auxiliary Contacts:

1. Provide contacts for connection to elevator controllers, one closed when transfer switch is connected to normal, and one closed when transfer switch is connected to emergency.
2. Provide additional contacts as necessary to accomplish the functions shown on the drawings, specified, and designated in other sections of these specifications and one spare normally open and normally closed contact.
3. Contacts shall have a minimum rating of ten amperes and be positive acting on pickup and dropout.

F. Remote Indicators:

1. Provide remote pilot lamps to show transfer switch position.
2. Provide remote manual test switch to simulate normal source failure.
3. Provide remote contact to bypass retransfer time delay to normal source.

G. In-Phase Band Monitor: Monitor shall control the operation of the transfer switch. It shall monitor the voltage and frequency of the normal and emergency voltage.

H. Auxiliary Relay: Provide an auxiliary pre-signal relay on all automatic transfer switches, which will feed elevator loads for use as elevator control.

2.4 TRANSFER SWITCH OPERATION

- A. Engine Start: A voltage decrease, at any transfer switch, in one or more phases of the normal power source to less than 70 percent of normal shall start the engine-generator unit after a time delay of two to three seconds. The time delay shall be field adjustable from zero to fifteen seconds.
- B. Transfer to Emergency (Emergency System Loads): Transfer switches for emergency system loads shall transfer their loads from normal to emergency source when frequency and voltage of the engine-generator unit have attained 90 percent of rated value. Only those switches with deficient normal source voltage shall transfer.
- C. Transfer to Emergency (Equipment System Loads): Transfer switches for equipment system loads shall transfer their loads to the generator on a time delayed staggered basis, after the emergency system switches have transferred. Total delayed transfer time of an equipment system switches shall not exceed two minutes. Time-delay relays shall be field adjustable zero to two minutes.
- D. Retransfer to Normal (All Loads): Transfer switch shall retransfer the load from emergency to normal source upon restoration of normal supply in all phases to 90 percent or more of normal voltage, and after a time delay. The time delay shall be field adjustable from five to twenty-five

minutes (preset for twenty-five minutes). Should the emergency source fail during this time, the transfer switch shall immediately transfer to the normal source whenever it becomes available. After restoring to normal source, the generator shall continue to run for five minutes unloaded before shut down. Time delay shall be adjustable from zero to fifteen minutes.

- E. Exercise Mode: Transfer to emergency power source shall be accomplished by remote manual test switches on a selective basis.

2.5 BYPASS/ISOLATION SWITCHES (BP/IS)

- A. Provide two-way bypass/isolation manual type switches. The BP/IS shall permit load by-pass to either normal or emergency power source and complete isolation of the transfer switch, independent of transfer switch position. The switches shall conveniently and electrically bypass and isolate automatic transfer switches, which could not otherwise be safely maintained without disruption of critical loads. Bypass and isolation shall be possible under all conditions including where the automatic transfer switch may be removed from service. Bypass/Isolation switches shall comply with NFPA 110, and shall be factory tested.
- B. Operation: The bypass/isolation switch shall have provisions for operation by one person through the movement of a maximum of two handles at a common dead front panel in no more than 15 seconds or less. Provide a lock, which must energize to unlock the bypass switch, to prevent bypassing to a dead source. Provide means to prevent simultaneous connection between normal and emergency sources.
1. Bypass to normal (or emergency): Operation of bypass handle shall allow direct connection of the load to the normal (or emergency) source, without load interruption or by using a break-before-make design, or provide separate load interrupter contacts to momentarily interrupt the load.
 - a. Assure continuity of auxiliary circuits necessary for proper operation of the system.
 - b. A red indicating lamp shall light when the automatic transfer switch is bypassed.
 - c. Bypassing source to source: If the power source is lost while in the bypass position, bypass to the alternate source shall be achievable without re-energization of the automatic transfer switch service and load connections.
 2. Isolation: Operation of the isolating handle shall isolate all live power conductors to the automatic transfer switch without interruption of the load.

- a. Interlocking: Provide interlocking as part of the bypass/isolation switch to eliminate personnel-controlled sequence of operation, and to prevent operation to the isolation position until the bypass function has been completed.
- b. Padlocking: Include provisions to padlock the isolating handle in the isolated position.
- c. Visual verification: The isolation blades shall be visible in the isolated position.
- 3. Testing: It shall be possible to test (normal electrical operation) the automatic transfer switch and engine generator with the isolation contacts closed, and the load bypassed without interruption of power to the load.
- C. Ratings: The electrical capabilities and ratings of the bypass/isolation switch shall be compatible with those of the associated automatic transfer switch, including any required additional withstand tests.
- D. Enclosure Construction: Enclosure construction shall be in accordance with UL standards. The bypass/isolation switch shall be mounted in a separate enclosure or separate compartment from the automatic transfer switch. NEMA ICS 6 enclosure rating shall match automatic transfer switch.
- E. Diagrams: The manufacturer shall provide specific information on the interconnection and installation of the bypass/isolation switch and automatic transfer switch.
- F. The bypass/isolation switch shall also meet all the requirements as specified for an automatic transfer switch.

2.6. SPARE PARTS

- A. Provide six control fuses for each automatic transfer switch of different rating.
- B. Provide six pilot lamps of each type used.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install automatic transfer switch(s) in accordance with the NFPA and as shown on the drawings.
- B. Level and anchor the automatic transfer(s) switch to floor or wall.
- C. Ground equipment as shown on the drawings and as required by NFPA 70.

3.2 START UP AND TESTING

- A. After the complete system has been installed, and before energizing the system, check all components of the system, including insulation resistance, phase to phase and phase to ground, complete electrical

circuitry and safety features according to the manufacturer's written instructions.

- B. After energizing circuits, test the interlocking sequence and operation of the complete system, including time delays of transfer from normal source to emergency and back to normal source, pick-up and voltage drop, and function of bypass/isolation switch in the presence of the COTR prior to the final inspection.
- C. When any defects are detected, correct the defects and repeat the test as requested by the COTR, at no additional cost to the Government.

3.3 DEMONSTRATION

At the final inspection in the presence of a VA representative, demonstrate that the complete auxiliary electrical power system operates properly in every respect. Coordinate this demonstration with the demonstration of the engine-generator set.

3.4 TRAINING

Furnish the services of a competent, factory-trained engineer or technician for one four-hour period for instructing VA personnel in operation and maintenance of the equipment, including review of the operation and maintenance manual, on a date requested by the COTR. Coordinate this training with that of the generator training.

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SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL**1.1 DESCRIPTION**

This section specifies the furnishing and installation of a complete master labeled lightning protection system, complying with NFPA 780, UL 96 and UL 96A.

1.2 RELATED WORK

- A. Section 07 60 00, FLASHING AND SHEET METAL: penetrations through the roof.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground faults.
- D. Section 26 42 00 CATHODIC PROTECTION: Requirements for protection of buried ferrous equipment from galvanic corrosion.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Isometric and plan views showing layout and connections to the required metal surfaces.
 - 2. Show the methods of mounting the system to the adjacent construction.
- C. Qualifications: Submit proof that the installer of the lightning protection system is a certified Lightning Protection Institute (LPI) installer, and has had suitable and adequate experience installing other lightning protection systems, and is capable of installing the system as recommended by the manufacturer of the equipment.
- D. Certification: Two weeks prior to final inspection, submit four copies of the following certifications to the COTR:
 - 1. Certification that the lightning protection system has been properly installed and tested.

2. Certification that the lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
 - B. National Fire Protection Association (NFPA):
 - 70.....National Electrical Code (NEC)
 - 780.....Standard for the Installation of Lightning Protection Systems
 - C. Underwriters Laboratories, Inc. (UL):
 - 96.....Lightning Protection Components
 - 96A.....Installation Requirements for Lightning Protection Systems
- UL 467Standard for Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Attach master labels to each item by its manufacturer as evidence that the materials have been manufactured in conformance with the UL Standards for master label lightning protection materials.
- B. In addition to conformance to UL 96, the component material requirements are as follows:
 1. Conductors: Electrical grade copper. Conductors shall be in accordance with NFPA 780 and UL 96 for Class I, Class II, or Class II modified materials as applicable.
 2. Air terminals: Solid copper, 18 inches long, not less than 3/8 inch [9mm] diameter, with sharp nickel-plated points.
 3. Ground rods: Copper clad steel, not less than 1/2 inch [13mm] diameter by 8 feet [2400mm] long. Rods made of copper-clad steel shall conform to UL 467 and galvanized ferrous rods shall conform to IEEE C135.30. Ground rods of copper-clad steel, steel, stainless steel, galvanized ferrous, and solid copper shall not be mixed on the project.
 4. Ground plates: Solid copper, not less than 1/16 inch [2mm] thick.
 5. Tubing: Stiff copper or brass.
- C. Anchors and fasteners: Bolt type which are most suitable for the specific anchor and fastener installations. Clamp-type connectors for splicing conductors shall conform to UL 96, class as applicable, and, Class 2, style and size as required for the installation. Clamp-type

connectors shall only be used for the connection of the roof conductor to the air terminal and to the guttering. All other connections, bonds, and splices shall be done by exothermic welds or by high compression fittings. The exothermic welds and high compression fittings shall be listed for the purpose. The high compression fittings shall be the type which require a hydraulically operated mechanism to apply a minimum of 10,000 psi.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be coordinated with the roofing manufacturer and installer.
- B. Install the conductors as inconspicuously as practical and with the proper bends.
- C. Install the vertical conductors within the concealed cavity of exterior walls. Run the conductors to the exterior at elevations below the finished grade and make the ground connections to the earth outside of the building or stack perimeter.
- D. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.
- E. Use the exothermic welding type connections that form solid metal joints in the main vertical and horizontal conductors, and for connections that are not exposed in the finish work.
- F. Protect copper conductors with stiff copper or brass tubing, which enclose the conductors from the top to the bottom of the tubing, between one foot [300mm] below and seven feet [2100mm] above the finished grade. The conductor shall be bonded to the top and bottom of the tubing.
- G. Sheath copper conductors, which pass over cast stone, cut stone, architectural concrete and masonry surfaces, with not less than a 1/16 inch [2mm] thickness of lead to prevent staining of the exterior finish surfaces.
- H. For the earth connections, install ground rods and ground plates, and the conductor connections to them and the main water pipes in the presence of the COTR. For the conductors located outside of the building or stack, install the conductors not less than two feet [600mm] below the finished grade.
- I. For structural steel buildings, connect the steel framework of the buildings to the main water pipe near the water system entrance to the building.
- J. Connect lightning protection cables to all metallic projections, equipment, and components above the roof as indicated on the drawings.

- K. Connect exterior metal surfaces, located within three feet [900mm] of the lightning protection system conductors, to the lightning protection system conductors to prevent flashovers.
- L. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least an 8-inch radius and do not exceed 90 degrees.
- M. Conductors shall be rigidly fastened every three feet [900mm] along the roof and down to the building to ground.
- N. Air terminals shall be secured against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure. Install air terminal bases, cable holders and other roof-system supporting means without piercing roof metal.
- O. Use clamp supports to secure supporting means to roof standing seams only.
- P. Use through-roof connectors for down-conductor attachment to roof system. Provide flashing in accordance with Section 07 60 00, FLASHING AND SHEET METAL.
- Q. Down-conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 100 feet [30m].
- R. A counterpoise, where shown, shall be of No. 1/0 copper cable or equivalent material having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 2 feet [600mm] deep at a distance not less than 3 feet [900mm] nor more than 8 feet [2.5m] from the nearest point of the structure.
- S. On construction utilizing post tensioning systems to secure precast concrete sections, the post tension rods shall not be used as a path for lightning to ground. Down conductors shall be provided on structures using post tensioning systems. Down conductors shall have sufficient separation from post tension rods to prevent side-flashing. Post tension rods shall be bonded to the lightning protection and grounding systems only at the base of the structure; this bonding shall be performed in strict accordance with the recommendations of the post tension rod manufacturer, and shall be done by, or in the presence of, a representative of the manufacturer.

- T. Grounding: Test the ground resistance to earth by standard methods and conform to the ground resistance requirements specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- U. Where shown, use the structural steel framework or reinforcing steel as the main conductor:
1. Weld or bond the non-electrically-continuous sections together and make them electrically continuous.
 2. Verify the electrical continuity by measuring the ground resistances to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings.
 3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 60 foot [18m] intervals.
 4. Install ground connections to earth at not more than 60 foot [18m] intervals around the perimeter of the building.
 5. Weld or braze bonding plates, not less than 8 inches [200mm] square, to cleaned sections of the steel and connect the conductors to the plates.
 6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to UL Publication No. 96A.
- V. When the lightning protection systems have been installed, have the systems inspected by a UL representative. Obtain and install a UL numbered master label for each of the lightning protection systems at the location directed by the UL representative and the COTR.
- W. Metal fences that are electrically continuous with metal posts extending at least 2 feet [600mm] into the ground require no additional grounding. Other fences shall be grounded on each side of every gate. Fences shall be grounded by means of ground rods every 1000 to 1500 feet [300 to 450m] of length when fences are located in isolated places, and every 500 to 750 feet [150 to 225m] when in proximity (100 feet [30m] or less) to public roads, highways, and buildings.

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SECTION 26 43 13**TRANSIENT-VOLTAGE SURGE SUPPRESSION****PART 1 - GENERAL****1.1 DESCRIPTION**

Section includes transient voltage surge suppression equipment for low-voltage power distribution and control equipment.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- B. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: For factory-installed TVSS.
- C. Section 26 24 11, DISTRIBUTION SWITCHBOARDS: For factory-installed TVSS.
- D. Section 26 24 16, PANELBOARDS: For factory-installed TVSS.
- E. Section 26 26 00, POWER DISTRIBUTION UNITS FOR UNINTERRUPTIBLE POWER SYSTEMS: For factory-installed TVSS.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
- B. Operation and Maintenance Data: For TVSS devices to include in emergency, operation, and maintenance manuals.
- C. Warranties: Sample of special warranties.
- D. Certifications:
 - 1. Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - a. Certification by the Contractor that the assemblies have been properly installed, adjusted and tested.
 - b. Certified copies of all of the factory design and production tests, field test data sheets and reports for the assemblies.

1.5 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

- A. Institute of Engineering and Electronic Engineers (IEEE):

IEEE C62.41.2.....Recommended Practice on Characterization
of Surges in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.45.....Recommended Practice on Surge Testing for
Equipment Connected to Low-Voltage (1000
V and Less) AC Power Circuits

B. National Electrical Manufacturers Association (NEMA):

NEMA LS 1.....Low Voltage Surge Protective Devices

C. Underwriters Laboratories, Inc. (UL):

UL 1283.....Electromagnetic Interference Filters

UL 1449.....Surge Protective Devices

D. National Fire Protection Association (NFPA):

NFPA 70.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 SWITCHGEAR/SWITCHBOARD SUPPRESSORS

A. Surge Protection Devices:

1. Comply with UL 1449.
2. Modular design with field-replaceable modules.
3. Fuses, rated at 200-kA interrupting capacity.
4. Fabrication using bolted compression lugs for internal wiring.
5. Integral disconnect switch.
6. Redundant suppression circuits.
7. Redundant replaceable modules.
8. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
9. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
10. LED indicator lights for power and protection status.
11. Audible alarm, with silencing switch, to indicate when protection has failed.
12. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
13. Four-digit transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 240 kA per mode/480 kA per phase.

- C. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
1. Line to Neutral: 70,000 A.
 2. Line to Ground: 70,000 A.
 3. Neutral to Ground: 50,000 A.
- D. Protection modes and UL 1449 SVR for grounded wye circuits shall be as follows:
1. Line to Neutral: 800 V for 480Y/277 V, 400 V for 208Y/120 V.
 2. Line to Ground: 800 V for 480Y/277 V, 400 V for 208Y/120 V.
 3. Neutral to Ground: 800 V for 480Y/277 V, 400 V for 208Y/120 V.
- E. Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:
1. Line to Neutral: 400 V.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- F. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
1. Line to Neutral: 400 V, 800 V from high leg.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- G. Protection modes and UL 1449 SVR for 240 V or 480 V, 3-phase, 3-wire, delta circuits shall be as follows:
1. Line to Line: 2000 V for 480 V, 1000 V for 240 V.
 2. Line to Ground: 2000 V for 480 V, 1000 V for 240 V.

2.2 PANELBOARD SUPPRESSORS

- A. Surge Protection Devices:
1. Non-modular.
 2. LED indicator lights for power and protection status.
 3. Audible alarm, with silencing switch, to indicate when protection has failed.
- B. Peak Single-Impulse Surge Current Rating: 120 kA per mode/240 kA per phase.
- C. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:
1. Line to Neutral: 70,000 A.
 2. Line to Ground: 70,000 A.
 3. Neutral to Ground: 50,000 A.

- D. Protection modes and UL 1449 SVR for grounded wye circuits shall be as follows:
1. Line to Neutral: 800 V for 480Y/277 V, 400 V for 208Y/120 V.
 2. Line to Ground: 800 V for 480Y/277 V, 400 V for 208Y/120 V.
 3. Neutral to Ground: 800 V for 480Y/277 V, 400 V for 208Y/120 V.
- E. Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
1. Line to Neutral: 400 V.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- F. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
1. Line to Neutral: 400 V, 800 V from high leg.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- G. Protection modes and UL 1449 SVR for 240 V or 480 V, 3-phase, 3-wire, delta circuits shall be as follows:
1. Line to Line: 2000 V for 480 V, 1000 V for 240 V.
 2. Line to Ground: 1500 V for 480 V, 800 V for 240 V.

2.3 ENCLOSURES

- A. Indoor Enclosures: NEMA 250 Type 1.
- B. Outdoor Enclosures: NEMA 250 Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install TVSS devices at switchboard, switchgear, or panelboard on load side, with ground lead bonded to service entrance ground.
- B. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
1. Provide a circuit breaker, sized by manufacturer, as a dedicated disconnecting means for TVSS unless otherwise shown on drawings.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate data with specifications and approved shop drawings.

- b. Inspect physical, electrical, and mechanical condition.
- c. Verify that disconnecting means and feeder size and maximum to TVSS unit correspond to approved shop drawings.
- d. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
- e. Clean TVSS unit.
- f. Complete startup checks according to manufacturer's written instructions.
- g. Verify the correct operation of all sensing devices, alarms, and indicating devices.

3.3 STARTUP

- A. Do not energize or connect switchgear, switchboards, or panelboards to their sources until TVSS devices are installed and connected.
- B. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 SPARE PARTS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Replaceable Protection Modules: One of each size and type installed.

3.5 INSTRUCTION

Provide factory certified technician to train Government maintenance personnel to maintain TVSS devices. Training shall be provided for a total period of 4 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance test. Training shall cover all essential items contained in the operation and maintenance manual.

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SECTION 26 51 00
INTERIOR LIGHTING**PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation and connection of the interior lighting systems.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- D. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Product Data: For each type of lighting fixture (luminaire) designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of fixture designation, submit the following information.
 - 1. Material and construction details include information on housing, optics system and lens/diffuser.
 - 2. Physical dimensions and description.
 - 3. Wiring schematic and connection diagram.
 - 4. Installation details.
 - 5. Energy efficiency data.
 - 6. Photometric data based on laboratory tests complying with IESNA Lighting Measurements, testing and calculation guides.
 - 7. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours) and color temperature (degrees Kelvin).
 - 8. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts and total harmonic distortion (THD).

C. Manuals:

1. Submit, simultaneously with the shop drawings companion copies of complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.
2. Two weeks prior to the final inspection, submit four copies of the final updated maintenance and operating manuals, including any changes, to the COTR.

D. Certifications:

1. Two weeks prior to final inspection, submit four copies of the following certifications to the COTR:
 - a. Certification by the Contractor that the equipment has been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
C62.41-91.....Guide on the Surge Environment in Low Voltage
(1000V and less) AC Power Circuits
- C. National Fire Protection Association (NFPA):
70.....National Electrical Code (NEC)
101.....Life Safety Code
- D. National Electrical Manufacturer's Association (NEMA):
C82.1-97.....Ballasts for Fluorescent Lamps - Specifications
C82.2-02.....Method of Measurement of Fluorescent Lamp
Ballasts
C82.4-02.....Ballasts for High-Intensity-Discharge and Low-
Pressure Sodium Lamps
C82.11-02.....High Frequency Fluorescent Lamp Ballasts
- E. Underwriters Laboratories, Inc. (UL):
496-96.....Edison-Base Lampholders
542-99.....Lampholders, Starters, and Starter Holders for
Fluorescent Lamps
844-95.....Electric Lighting Fixtures for Use in Hazardous
(Classified) Locations
924-95.....Emergency Lighting and Power Equipment
935-01.....Fluorescent-Lamp Ballasts
1029-94.....High-Intensity-Discharge Lamp Ballasts
1029A-06.....Ignitors and Related Auxiliaries for HID Lamp
Ballasts

1598-00.....Luminaires
1574-04.....Standard for Track Lighting Systems
2108-04.....Standard for Low-Voltage Lighting Systems
8750-08.....Light Emitting Diode (LED) Light Sources for Use
in Lighting Products

F. Federal Communications Commission (FCC):

Code of Federal Regulations (CFR), Title 47, Part 18

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES (LUMINAIRES)

- A. Shall be in accordance with NFPA 70 and UL 1598, as shown on drawings, and as specified.
- B. Sheet Metal:
1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved) and parallel to each other as designed.
 2. Wireways and fittings shall be free of burrs and sharp edges and shall accommodate internal and branch circuit wiring without damage to the wiring.
 3. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
 4. Hinged door closure frames shall operate smoothly without binding when the fixture is in the installed position, latches shall function easily by finger action without the use of tools.
- C. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.
- D. Lamp Sockets:
1. Fluorescent: Lampholder contacts shall be the biting edge type or phosphorous-bronze with silver flash contact surface type and shall conform to the applicable requirements of UL 542. Lamp holders for bi-pin lamps shall be of the telescoping compression type, or of the single slot entry type requiring a one-quarter turn of the lamp after insertion.
 2. High Intensity Discharge (H.I.D.): Shall have porcelain enclosures.
- E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.
- F. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive

screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

G. Metal Finishes:

1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
3. Exterior finishes shall be as shown on the drawings.

H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.

I. Light Transmitting Components for Fluorescent Fixtures:

1. Shall be 100 percent virgin acrylic.
2. Flat lens panels shall have not less than 1/8 inch [3.2mm] of average thickness. The average thickness shall be determined by adding the maximum thickness to the minimum unpenetrated thickness and dividing the sum by 2.
3. Unless otherwise specified, lenses, diffusers and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction of the lens without distortion or cracking.

J. Lighting fixtures in hazardous areas shall be suitable for installation in Class and Group areas as defined in NFPA 70, and shall comply with UL 844.

K. Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballast integral to the fixture. Assemblies designed to retrofit incandescent fixtures are prohibited except when specifically indicated for renovation of existing fixtures (not the lamp). Fixtures shall be designed for lamps as specified.

2.2 BALLASTS

A. Linear Fluorescent Lamp Ballasts: Multi-voltage (120 - 277V) electronic programmed-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated; including the following features:

1. Lamp end-of-life detection and shutdown circuit (T5 lamps only).
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: Class A.
 4. Total Harmonic Distortion Rating: 10 percent or less.
 5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. Ballast Factor: 0.87 or higher unless otherwise indicated.
 9. Power Factor: 0.98 or higher.
 10. Interference: Comply with 47 CFT 18, Ch.1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 11. To facilitate multi-level lamp switching, lamps within fixture shall be wired with the outermost lamp at both sides of the fixture on the same ballast, the next inward pair on another ballast and so on to the innermost lamp (or pair of lamps). Within a given room, each switch shall uniformly control the same corresponding lamp (or lamp pairs) in all fixture units that are being controlled.
 12. Where three-lamp fixtures are indicated, unless switching arrangements dictate otherwise, utilize a common two-lamp ballast to operate the center lamp in pairs of adjacent units that are mounted in a continuous row. The ballast fixture and slave-lamp fixture shall be factory wired with leads or plug devices to facilitate this circuiting. Individually mounted fixtures and the odd fixture in a row shall utilize a single-lamp ballast for operation of the center lamp.
 13. Dimming ballasts shall be as per above, except dimmable from 100% to 5% of rated lamp lumens.
- B. Low-Frequency Linear T8 Fluorescent Lamp Ballasts (allowed for Surgery Suites, Critical Care Units and Animal Labs): //120V// //277V// hybrid electronic-electromagnetic rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output; including the following features:
1. Automatic lamp starting after lamp replacement.
 2. Sound Rating: Class A.
 3. Total Harmonic Distortion Rating: 20 percent or less.
 4. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.

5. Operating Frequency: 60 Hz.
 6. Lamp Current Crest Factor: 1.7 or less.
 7. Ballast Factor: 0.85 or higher unless otherwise indicated.
 8. Power Factor: 0.90 or higher.
 9. Interference: Comply with 47 CFT 18, Ch.1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 10. To facilitate multi-level lamp switching, lamps within fixture shall be wired with the outermost lamp at both sides of the fixture on the same ballast, the next inward pair on another ballast and so on to the innermost lamp (or pair of lamps). Within a given room, each switch shall uniformly control the same corresponding lamp (or lamp pairs) in all fixture units that are being controlled.
 11. Where three-lamp fixtures are indicated, unless switching arrangements dictate otherwise, utilize a common two-lamp ballast to operate the center lamp in pairs of adjacent units that are mounted in a continuous row. The ballast fixture and slave-lamp fixture shall be factory wired with leads or plug devices to facilitate this circuiting. Individually mounted fixtures and the odd fixture in a row shall utilize a single-lamp ballast for operation of the center lamp.
- C. Compact Fluorescent Lamp Ballasts: Multi-voltage (120 - 277V), electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated; including the following features:
1. Lamp end-of-life detection and shutdown circuit.
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: Class A.
 4. Total Harmonic Distortion Rating: 10 percent or less.
 5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. Ballast Factor: 0.95 or higher unless otherwise indicated.
 9. Power Factor: 0.98 or higher.
 10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.

11. Dimming ballasts shall be as per above, except dimmable from 100% to 5% of rated lamp lumens.
- D. Ballasts for high intensity discharge fixtures: Multi-tap voltage (120-480v) electromagnetic ballast for high intensity discharge lamps. Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:
 1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
 3. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
 4. Open-circuit operation that will not reduce average life.
 5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- E. Electronic ballast for high intensity discharge metal-halide lamps shall include the following features unless otherwise indicated:
 1. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
 2. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
 3. Lamp end-of-life detection and shutdown circuit.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: 20 percent or less.
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Lamp Current Crest Factor: 1.5 or less.
 8. Power Factor: 0.90 or higher.
 9. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 10. Protection: Class P thermal cut.

2.3 EMERGENCY LIGHTING UNIT

- A. Complete, self-contained unit with batteries, battery charger, one or more local or remote lamp heads with lamps, under-voltage relay, and test switch. Comply with UL 924.
 1. Enclosure: Shall be impact-resistant thermoplastic, which will protect components from dust, moisture, and oxidizing fumes from the battery. Enclosure shall be suitable for the environmental conditions in which installed.
 2. Lamp Heads: Horizontally and vertically adjustable, mounted on the face of the unit, except where otherwise indicated.

3. Lamps: Shall be sealed-beam MR-16 halogen, rated not less than 1 watts at the specified DC voltage.
4. Battery: Shall be maintenance-free nickel-cadmium. Minimum normal life shall be 10 years.
5. Battery Charger: Dry-type full-wave rectifier with charging rates to maintain the battery in fully-charged condition during normal operation, and to automatically recharge the battery within 12 hours following a 1-1/2 hour continuous discharge.
6. Integral Self-Test: Automatically initiates test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing LED.

2.4 LAMPS

A. Linear and U-shaped T5 and T8 Fluorescent Lamps:

1. Rapid start fluorescent lamps shall comply with ANSI C78.1; and instant-start lamps shall comply with ANSI C78.3.
2. Chromacity of fluorescent lamps shall comply with ANSI C78.376.
3. Except as indicated below, lamps shall be low-mercury energy saving type, have a color temperature between 3500° and 4100°K, a Color Rendering Index (CRI) of greater than 70, average rated life of 20,000 hours, and be suitable for use with dimming ballasts, unless otherwise indicated. Low mercury lamps shall have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.
 - a. Over the beds in Intensive Care, Coronary Care, Recovery, Life Support, and Observation and Treatment areas; Electromyographic, Autopsy (Necropsy), Surgery, and certain dental rooms (Examination, Oral Hygiene, Oral Surgery, Recovery, Labs, Treatment, and X-Ray) use color corrected lamps having a CRI of 85 or above and a correlated color temperature between 5000 and 6000°K.
 - b. Other areas as indicated on the drawings.

B. Compact Fluorescent Lamps:

1. T4, CRI 80 (minimum), color temperature 3500 K, and suitable for use with dimming ballasts, unless otherwise indicated.

C. Long Twin-Tube Fluorescent Lamps:

1. T5, CRI 80 (minimum), color temperature between 3500° and 4100°K, 20,000 hours average rated life.

2. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000°K.
3. Ceramic, Pulse-Start, Metal-Halide Lamps: CRI 80 (minimum), and color temperature 4000°K.

2.5 RADIO-INTERFERENCE-FREE FLUORESCENT FIXTURES

- A. Shall be specially designed for suppressing radio-frequency energy produced within the fixtures. The Rules and Regulations of FCC (CFR 47, Part 18) shall apply.
- B. Lenses shall have a light-transparent layer of metal permanently bonded to them, and in positive contact with the steel housing or equal to prevent the radio-frequency interferences from passing through the lenses. The effective light transmittance of the lenses shall be not less than 75 percent.
- C. Install line filters within the body of the fixtures and wired in series with the supply circuit conductors to eliminate the transmission of radio frequency energy into the supply circuit.
- D. Ballasts shall be as specified herein.

2.6 EXIT LIGHT FIXTURES

- A. Exit light fixtures shall meet applicable requirements of NFPA 101 and UL 924.
- B. Housing and Canopy:
 1. Shall be made of die-cast aluminum.
 2. Optional steel housing shall be a minimum 20 gauge thick or equivalent strength aluminum.
 3. Steel housing shall have baked enamel over corrosion resistant, matte black or ivory white primer.
- C. Door frame shall be cast or extruded aluminum, and hinged with latch.
- D. Finish shall be satin or fine-grain brushed aluminum.
- E. There shall be no radioactive material used in the fixtures.
- F. Fixtures:
 1. Maximum fixture wattage shall be 1 watt or less.
 2. Inscription panels shall be cast or stamped aluminum a minimum of 0.090 inch [2.25mm] thick, stenciled with 6 inch [150mm] high letters, baked with red color stable plastic or fiberglass. Lamps shall be luminous Light Emitting Diodes (LED) mounted in center of letters on red color stable plastic or fiberglass. The LED shall be rated minimum 25 years life.
 3. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.

4. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.

G. Voltages: Refer to Lighting Fixture Schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions and as shown on the drawings or specified.
- B. Align, mount and level the lighting fixtures uniformly.
- C. Fluorescent bed light fixtures shall be attached to the studs in the walls. Attachment to gypsum board only is not acceptable.
- D. Lighting Fixture Supports:
 1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
 2. Shall maintain the fixture positions after cleaning and relamping.
 3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
 4. Hardware for recessed fluorescent fixtures:
 - a. Where the suspended ceiling system is supported at the four corners of the fixture opening, hardware devices shall clamp the fixture to the ceiling system structural members, or plaster frame at not less than four points in such a manner as to resist spreading of the support members and safely lock the fixture into the ceiling system.
 - b. Where the suspended ceiling system is not supported at the four corners of the fixture opening, hardware devices shall independently support the fixture from the building structure at four points.
 5. Hardware for surface mounting fluorescent fixtures to suspended ceilings:
 - a. In addition to being secured to any required outlet box, fixtures shall be bolted to a grid ceiling system at four points spaced near the corners of each fixture. The bolts shall be not less than 1/4 inch [6mm] secured to channel members attached to and spanning the tops of the ceiling structural grid members. Non-turning studs may be attached to the ceiling structural grid members or spanning

channels by special clips designed for the purpose, provided they lock into place and require simple tools for removal.

- b. In addition to being secured to any required outlet box, fixtures shall be bolted to ceiling structural members at four points spaced near the corners of each fixture. Pre-positioned 1/4 inch [6mm] studs or threaded plaster inserts secured to ceiling structural members shall be used to bolt the fixtures to the ceiling. In lieu of the above, 1/4 inch [6mm] toggle bolts may be used on new or existing ceiling provided the plaster and lath can safely support the fixtures without sagging or cracking.

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SECTION 26 56 00**EXTERIOR LIGHTING****PART 1 - GENERAL****1.1 DESCRIPTION**

This section specifies the furnishing, installation, and connection of exterior luminaries, controls, poles and supports.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
- D. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground handholes and conduits.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting, details, materials, required clearances, terminations, wiring and connection diagrams, photometric data, ballasts, poles, luminaries, lamps and controls.
- C. Manuals: Two weeks prior to final inspection, submit four copies of operating and maintenance manuals to the COTR. Include technical data sheets, wiring and connection diagrams, and information for ordering replacement parts.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - 1. Certification that the materials are in accordance with the drawings and specifications.

2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

1.4 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

A. Aluminum Association Inc. (AA):

AAH35.1-2006Alloy and Temper Designation Systems for
Aluminum

B. American Association of State Highway and Transportation Officials
(AASHTO):

LTS-4-2003Structural Supports for Highway Signs,
Luminaries and Traffic Signals

C. American Concrete Institute (ACI):

318-2005Building Code Requirements for Structural
Concrete

D. American National Standards Institute (ANSI):

C57.12-2000.....General Requirements For Liquid-Immersed
Distribution, Power, and Regulating
Transformers

C81.61-2005Electrical Lamp Bases

E. American Society for Testing and Materials (ASTM):

A123/A123M-2002Zinc (Hot-Dip Galvanized) Coatings on Iron and
Steel Products

A153/A153M-2001.....Zinc Coating (Hot-Dip) on Iron and Steel
Hardware - AASHTO No.: M232

B108-03a -2003Aluminum-Alloy Permanent Mold Castings

D3487-2000.....Mineral Insulating Oil Used in Electrical
Apparatus

F. Federal Aviation Administration (FAA):

AC 70/7460-IK CHG 1-2000.....Obstruction Lighting and Marking

AC 150/5345-43E-1995....Specification for Obstruction Lighting
Equipment

G. Illuminating Engineering Society of North America (IESNA)

HB-9-2000.....Lighting Handbook

RP-8-2000 (R-2005).....Roadway Lighting

H. National Electrical Manufacturers Association (NEMA):

- C78.41-2001.....Electric Lamps - Guidelines for Low-Pressure Sodium Lamps
 - C78.42-2004Electric Lamps - Guidelines for High-Pressure Sodium Lamps
 - C78.43-2005Electric Lamps - Single-Ended Metal-Halide Lamps
 - C78.1381-1998.....(R 1997) Electric Lamps - 70-Watt M85 Metal-Halide Lamps
 - C82.4-2002Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
 - C136.17-2005Roadway Lighting Equipment - Enclosed Side-Mounted Luminaries for Horizontal-Burning High-Intensity-Discharge Lamps
 - ICS 2-2005Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts
 - ICS 6-2001Industrial Control and Systems Enclosures
- I. National Fire Protection Association (NFPA):
- 70-2005National Electrical Code (NEC)
- J. Underwriters Laboratories, Inc. (UL):
- 496-2004Edison-Base Lamp holders
 - 773-1995.....Plug-in, Locking Type Photo controls, for Use with Area Lighting
 - 773A-2006Non-industrial Photoelectric Switches for Lighting Control
 - 1029-1994.....High-Intensity-Discharge Lamp Ballasts
 - 1598-2004Luminaries

1.5 DELIVERY, STORAGE, AND HANDLING

Aluminum Poles: Do not store poles on ground. Store poles so they are at least 305 mm (one foot) above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

PART 2 - PRODUCTS**2.1 MATERIALS AND EQUIPMENT**

Materials and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.

2.2 POLES

A. General:

1. Poles shall be round aluminum, as shown on the drawings, and as specified. Finish shall be as specified on the drawings.
2. The pole and arm assembly shall be designed for wind loading of 161 km/hr (100 miles per hour), with an additional 30 percent gust factor, supporting luminaire(s) having the effective projected areas indicated. The effective projected area of the pole shall be applied at the height of the pole base as shown on the drawings.
3. Poles shall be anchor-bolt type designed for use with underground supply conductors. Poles shall have oval-shaped handhole having a minimum clear opening of 65 by 125 mm (2.5 by 5 inches). Handhole cover shall be secured by stainless steel captive screws.
4. Provide a steel-grounding stud opposite hand hole openings.
5. Provide a base cover matching the pole in material and color to conceal the mounting hardware pole-base welds and anchor bolts.
6. Hardware: All necessary hardware shall be 300 series stainless steel.

B. Types:

1. Aluminum: Provide aluminum poles manufactured of corrosion resistant AA AAH35.1 aluminum alloys conforming to AASHTO LTS-4 for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys, and Alloy 356-T4 (3,5) for ASTM B108-03 cast alloys. Poles shall be seamless extruded or spun seamless type. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Base covers for aluminum poles shall be cast from 356-T6 aluminum alloy in accordance with ASTM B108-03.

2.3 FOUNDATIONS FOR POLES

- A. Foundations shall be cast-in-place concrete.
- B. Foundations shall support the effective projected area of the specified pole, arm(s), and luminaire(s) under wind conditions previously specified in this section.
- C. Place concrete in spirally wrapped treated paper forms for round foundations, and construct forms for square foundations.
- D. Rub-finish and round all above-grade concrete edges to approximately 6 mm (1/4 inch) radius.
- E. Concrete shall have 3000 psi minimum 28 day compressive strength.
- F. Anchor bolt assemblies and reinforcing of concrete foundations shall be as shown on the drawings and meet ACI 318. Anchor bolts shall be in a welded cage or properly positioned by the tie wire to stirrups.

- G. Prior to concrete pour, install a copperclad steel ground rod, not less than 19 mm (3/4-inch) diameter by 3000 mm (10 feet) long, below each foundation. Drive the rod vertically under the foundation so not less than 1800 mm (6 feet) of rod is in contact with the earth. Remainder of rod may be in the concrete pour. Where rock or layered rock is present, drill a hole not less than 50 mm (2 inches) in diameter and 1800 mm (6 feet) deep, backfill with tamped fine sand and drive the rod into the hole. Bond the rod to the pole with not less than number 6 AWG bare copper wires. The method of bonding shall be approved for the purpose.

2.4 LUMINAIRES

- A. UL 1598 and NEMA C136.17. Luminaries shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat and safe cleaning and relamping.
- B. IESNA HB-9 and RP-8 light distribution pattern types shall be as shown on the drawings.
- C. Incorporate ballasts in the luminaire housing except where otherwise shown on the drawings.
- D. Lenses shall be frame-mounted heat-resistant, borosilicate glass, prismatic refractors. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging resistant resilient gaskets to seal and cushion lenses and refractors in luminary doors.
- E. Lamp sockets for high intensity discharge (H.I.D) fixture shall have locking type porcelain enclosures in conformance to the applicable requirements of ANSI C81.61 and UL 496.
- F. Pre-wire internal components to terminal strips at the factory.
- G. Bracket mounted luminaries shall have leveling provisions and clamp type adjustable slip-fitters with locking screws.
- H. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.
- I. IESNA Cutoff Category: Cutoff

2.5 LAMPS

- A. Install the proper lamps in every luminaire installed.
- B. Lamps to be general-service, outdoor lighting types.
- C. High-Pressure Sodium (HPS) Lamps: NEMA C78.42, wattage as indicated.
Lamps shall have average rated life of 16,000 hours minimum for 35 watt lamps and 24,000 hours minimum for all higher wattages.
- D. Low-Pressure Sodium (LPS) Lamps: NEMA C78.41.

E. Metal-Halide Lamps: NEMA C78.43 or NEMA C78.1381

F. Mercury vapor lamps shall not be used.

2.6 HIGH INTENSITY DISCHARGE BALLASTS

A. For low voltage systems, the ballasts shall be the high efficiency, high power factor, copper-wound constant wattage type and shall meet the requirements of UL 1029 and NEMA C82.4.

1. Ballasts shall operate the discharge lamp of the type, wattage, and voltage shown on the drawings.

2. Ballasts shall have individual overcurrent protection (inline fuse holder) as recommended by the ballast manufacturer.

3. Ballasts shall be capable of providing reliable starting of the lamps at minus 30 degrees C.

4. Open-circuit operation shall not reduce the average life.

B. Locate protective devices for ballasts to be accessible if the devices are not integral with ballasts.

C. Each ballast shall operate not more than one lamp except where otherwise shown on the drawings.

2.7 LIGHTING CONTACTORS

NEMA ICS 2, mechanically held contactors. Rate contactors as indicated. Provide in NEMA 4 enclosure conforming to NEMA ICS 6. Contactors shall have silver alloy double-break contacts and coil clearing contacts for mechanically held contactor and shall require no arcing contacts.

Provide contactors with hand-off-automatic selector switch.

2.8 CONTROLS

A. Each Lighting System:

1. Shall be controlled by one of the following methods as shown for each system on the drawings:

a. A photocell to act as the pilot device. The photocell shall be the type which fails safe to the closed position meeting UL 773 or 773A.

b. A time clock to act as the pilot device.

c. A combination, photocell-time clock to act as dual pilot devices connected in series. The photocell shall provide the "on" function at dusk and the time clock(s) shall control specific circuit "off" functions during dark hours.

d. A time clock to act as the pilot device for a circuit (or circuits) when luminaries are individually photocell controlled.

- e. The pilot devices shall control the power circuit through the contractor or relay as shown on the drawings.
2. Mount and connect photocells and time clocks as shown on the drawings.
3. Photocells shall have the following features:
 - a. Quick-response, cadmium-sulfide type.
 - b. A 15 to 30 second, built-in time delay to prevent response to momentary lightning flashes, car headlights or cloud movements.
 - c. Energizes the system when the north sky light decreases to approximately 1.5 footcandles, and maintains the system energized until the north sky light increases to approximately 3 to 5 foot candles.
4. Time clocks shall have the following features:
 - a. A 24-hour astronomic dial, motor-driven.
 - b. A spring-actuated, reserve power mechanism for operating the timer during electrical power failures and that automatically winds the spring when the electrical power is restored.
5. The arrangement and method of control and the control devices shall be as shown on the drawings.

2.9 EXISTING LIGHTING SYSTEMS

- A. For modifications or additions to existing lighting systems, the new components shall be compatible with the existing systems.
- B. New poles and luminaries shall have approximately the same configurations and dimensions as the existing poles and luminaries except where otherwise shown on the drawings.

2.10 AUXILIARY EQUIPMENT

- A. Parallel-Type Systems: Shall be supplied power as shown on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lighting in accordance with the NEC, as shown on the drawings, and in accordance with manufacturer's recommendations.
- B. Aluminum Poles:
 1. Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad 90 degrees at the bottom end. Provide galvanized nuts, washers, and ornamental covers for anchor bolts. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end

- of conduit. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
2. After the poles have been installed, shimmed and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 9 mm (3/8-inch) inside diameter, through the grout tight to the top of the concrete base for moisture weeping.
- C. Foundation Excavation: Depth shall be as indicated. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 150 mm (6 inch) maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.
- D. Photocell Switch Aiming: Aim switch according to manufacturer's recommendations.

3.2 GROUNDING

Ground noncurrent-carrying parts of equipment including metal poles, luminaries, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable and listed for this purpose.

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